CURRICULUM OF

Chemical Engineering

MS & Ph.D.

School of Chemical and Material Engineering
National University of Sciences and Technology, Islamabad

Contents

INTRODUCTION

After successful experience of BE Chemical the School of Chemical and Materials Engineering (SCME) launched MS Chemical Engineering from fall 2013. It has been observed that the continuation of higher education up the ladder in this area is the need of the hour.

The program shall not only cater for our own students but will attract students throughout the country. The rationale behind this program, which should be upgraded to PhD level in due course, is aimed at developing a pool of highly trained engineers with master degree to lead research and development activities in academic and industrial domains to the advancement of science and technology for the benefit and service of humankind/society.

MISSION

To produce graduates and qualified researchers in Chemical Engineeringdiscipline to fulfill the requirements of the chemical engineering sector in the country.

OBJECTIVES

This curriculum is designed to impart knowledge, skills and training in order to prepare graduates to have:

- To meet the needs of the society and demands of nation.
- To focus the principles of research in chemical engineering design and their application for sustainable development
- Knowledge of contemporary issues and ability to work in multidisciplinary teams
- Leadership skills to serve on managerial positions within chemical and associated industries
- Motivation to maintain and raise their level of engineering competence and achievement by engaging in lifelong learning

ELIGIBILITY CRITERIA

- Sixteen years of schooling or 4 years (minimum 124 credit hours) education after FA/FSc/A Level in relevant discipline
- The candidate should have bachelor degree in following disciplines:
  - Bachelors in Chemical Engineering
  - Bachelors in Petroleum Engineering
- GAT (General) conducted by NTS with at least 50 raw score or GRE (General) conducted by ETS, USA,with following minimum score separately in each section:-

Quantitative	650/800	151/170
Verbal	400/800	146/170
Analytical Writing	3.5/6.0	3.5/6.0

ASSESSMENT METHODOLOGY

Nature of Examination	**Duration**	**Frequency**	**Weighting (%age)**
End semester examination	2- 3 hours	1	40-50
One Hour Test(s)*	One hour	• 1 CH Course – minimum 1 OHT • 2-4 CHs Courses – minimum 2 OHTs	30-40
Quizzes	-	• 1 CH Course – minimum 2 • 2 CHs and above Courses – minimum 3	10-15
Assignments	Own time	-	5-10
Project(s)	Own time	-	10-20
Lab Work /Projects	3 contact hours	1 per week for each lab CH	70-80

* Mid Semester Examination will be held in lieu of OHTs during Summer Semester.

GRADING SCHEME

Letter Grade	Grade Points
A	4.00
B+	3.5
B	3.00
C+	2.5
C	2.00
F	0.00
I	Incomplete
W	Dropped

Structure of Program

Courses	**CHs**	**Credited / Non credited**
Foundation	As required	Non Credited
Core	9 CHs	Credited
Electives	15 CHs	“
Thesis	6 CHs	“
Total	**30 CHs**	**“**

Courses Being Offered

MS Courses

Course Codes	Course Title	CHs
Core Courses		
EME-921	MHMT in CHE	3
CHE-847	Chemical Kinetics& Reactor Design	3
CHE-843	Separation processes in CHE	3
Elective Courses (Any Five)		
EME-810	Materials Technology	3
ESE-801	Biofuel Engineering	3
EME-981	Advance Fuel Technology	3
CHE-873	Membrane Technology	3
EME-902	Numerical methods in CHE	3
CHE-853	Green Process Engineering	3
CHE-848	Gasification Processes	3
EME-803	Combustion and Propulsion	3
MSE-880	Corrosion and Protection	3
MSE-871	Polymer Engineering	3
ENE-809	Waste water treatment & Design	3
CSE-801	Computation Fluid Dynamics (CFD)	3
CHE-823	Advance Analytical Techniques	3
MSE-952	Materials for Biomedical Application	3
CHE-816	Molecular Nanotechnology	3
CHE-899	Thesis	6

Scheme of Studies

Course Code	Title	CHs
Semester I		
CHE-843	Separation processes in CHE	3
xxx	Elective	3
xxx	Elective	3
Semester II		
EME-921	MHMT in CHE	3
CHE-847	Chemical Kinetics& Reactor Design	3
xxx	Elective	3
Semester III		
xxx	Elective	3
xxx	Elective	3
Semester IV		
CHE-899	Master Thesis Research	6

Elective Courses		
EME-810	Materials Technology	3
EME-981	Advance Fuel Technology	3
CHE-873	Membrane Technology	3
EME-902	Numerical Methods in CHE	3
CHE-853	Green Process Engineering	3
CHE-848	Gasification Processes	3
EME-803	Combustion and Propulsion	3
MSE-880	Corrosion and Protection	3
MSE-871	Polymer Engineering	3
CSE-801	Computation Fluid Dynamics (CFD)	3
CHE-823	Advance Analytical Techniques	3
MSE-952	Materials for Biomedical Application	3

Courses-MS Chemical Engineering

CHE-843 Separation Processes in Chemical Engineering

Credit Hours: **3**

Pre-requisites: **Nil**

Course Objectives

- To give a unified approach of separation processes in chemical engineering.
- To discuss both mechanical and thermal separation processes with emphasis on the designing of separation equipment.
- To teach student about separation process at advance level.

Course Contents

- Introduction Separation of solid particles from fluids.
- Sedimentation of particles, Liquid filtration&Centrifugal separations
- Leaching and extraction, Gasabsorption&Azeotropic and extractive distillation
- Crystallization, Drying, Adsorption process&Ion exchange
- Chromatographic separation processes
- Details of lab work, workshops practice (if applicable).

Course Outcomes

- After studying the course, the graduate will be able to apply the attained knowledge in the research area related designing of separation equipment.

Recommended Reading (including Textbooks and Reference books)

- Chemical Engineering: Particle Technology and separation Processes Vol. 2, Coulson and Richardson
- Chemical Process Equipment: Selection and Design S.M. WalasMultistage Separation Process byF,M, Khoury

CHE-847 Chemical Kinetics & Reactor Design

Credit Hours: **3**

Pre-requisites: **Nil**

Course Objectives

- The course aims at:
  - Basic understanding of chemical reactor design
  - Methodologies that incorporate both scale-up and hazard analysis.

Course Contents

- Reaction mechanism and rate expressions&Thermodynamics of chemical reactions
- Reaction rate expressions&Fundamentals of reactor design
- Non-isothermal reactors&Fluid mixing in reactors
- Residence time distribution in flow reactors&Application of CFD in reactors
- Biochemical reactions&Safety in chemical reaction engineering
- Reactor sizing and scale up
- Details of lab work, workshops practice (if applicable).

Course Outcomes

- How to select the best reactor for any particular chemical reaction
- To estimate its size, to obtain the best operating conditions.

Recommended Reading (including Textbooks and Reference books)

- Modeling of chemical kinetics and reactor design By A.K. Coker
- Introduction to Chemical reaction engineering and kinetics By R.W. Missen, C.A. Mims, B. A. Saville
- Introduction to Chemical reaction engineering and kineticsbyJoel H. Ferziger, MilovanPerić
- Introduction to Chemical reaction engineering and kinetics By Panagiotis D. Christofides

CHE-873 Membrane Technology

Credit Hours: **3**

Pre-requisites: **Nil**

Course Objectives

- Introduction to membrane science and technology, in all engineering approaches for the transport of substances between two fractions with the help of permeable membranes.
- To acquaint mechanical separation processes for separating gaseous or liquid streams use membrane technology.

Course Contents

- IntroductionHistorical developments of membranes&Membrane types
- Membrane processes, Membrane transport theory&Solution-diffusion model
- Structure-permeability relation&Isotropic and an-isotropic membranes
- Metal membranes, Ceramic membranes &Liquid membranes
- Membrane modules, Concentration polarization&Cross flow
- Co-current and counter-current flows&Reverse Osmosis membranes
- Ultra filtration and Micro filtration membranes
- Evaporation and Gas separation membranes
- Application and process design&Medical applications of membranes
- Membrane reactors, Membrane contactors&Membrane distillation
- Details of lab work, workshops practice (if applicable)

Course Outcomes

- This course would make students familiar with the transport mechanism in:
  - Membrane
  - Membrane materials
  - Membrane preparation and diverse application of membranes in variety of separation processes.

Recommended Reading (including Textbooks and Reference books)

- Membrane Technology and applications By R.W. Baker
- Numerical Methods for Chemical EngineersBy K.J. Beers
- Handbook of membrane separation by Pabby, Rizvi, Sastre
- Handbook of membrane separationBy A. Constantis, N. Moustafui

CHE-853 Green Process Engineering

Credit Hours: 3

Pre-requisites: Nil

Course Objectives

- To improve the environmental performance and safety of chemical processes
- To reduce the risks to man and the environment of chemical products.
- The principles of sustainable and green process are described.
- To understand the important concepts such as waste minimizationand reductions in materials and energy consumption and in risk and hazard are introduced.
- Students will learn about the sustainable processes in chemical engineering.

Course Contents

- IntroductionPrinciples of green chemistry and sustainability&Waste minimization
- Reduction of materials use&Reduction of energy requirement
- Reduction of risk and hazards&Sustainable use of chemical feedstock
- Energy and water, Life cycle assessment&Bio-catalysis
- Green catalysis for process industry&Process intensification
- Fuel cells- clean energy technology for the future
- Supercritical CO2 for safer processes
- Extraction of natural products with superheated water
- Details of lab work, workshops practice (if applicable)

Course Outcomes

- The procedure related to reduction of environmental risks by introducing Green Process in all related areas of research.

Recommended Reading (including Textbooks and Reference books)

- Handbook of Green Chemistry and Technology By J. Clark and D. Macquarrie
- Handbook of Green Chemistry and Technology By WilliJäger, Rannacher, Warnatz
- Computational methods for fluid dynamics by Joel H. Ferziger, MilovanPerić
- Control and optimization of multiscale process systemsByPanagiotis,Christofides.

CHE-848 Gasification Processes

Credit Hours: **3**

Pre-requisites: **Nil**

Course Objectives

- To familiarize the graduate students with the gasification technology.
- To understand all aspects of gasification process, gasification kinetics, thermodynamic modeling, gasification process design&related technical and environmental issues

Course Contents

- Introduction to historical development of gasification&Thermodynamic of gasification
- Modeling of gasification process&Optimizing process conditions
- Kinetics of gasification and Reactor theory
- Feedstock and feedstock characteristics&Gasification processes
- Fluid bed gasifies, Oil gasification, Biomass gasification&Gasification of wastes
- Gasifies design and related technical issues&Auxiliary technologies
- Economics environmental and safety issues
- Details of lab work, workshops practice (if applicable)

Course Outcomes

- After doing this course, students will learn about all gasification techniques
- Will learn, how to apply them in the energy related projects of the industry.

Recommended Reading (including Textbooks and Reference books):

- GasificationByC. Higman and M. Vaan der Burgt
- Reactive flows, diffusion and transport: from experiments via mathematicalByWilliJäger, Rolf Rannacher, J. Warnatz
- Computational methods for fluid dynamics by Joel H. Ferziger, MilovanPerić
- Control and optimization of multiscale process systems By Panagiotis D. Christofides

CHE-823 Analytical Techniques in Chemical Engineering

Credit Hours: 3

Pre-requisites: Nil

Course Objectives

- The objective of this course is to summaries the principles of quantum mechanics.
- Explain aspects of spectroscopic instrumentation related to quantum mechanical principles

Course Contents

- Introduction and theory of chromatography&Planar chromatography
- Liquid chromatography (LC/HPLC)&Gas chromatography (GC)
- Spectroscopic detection Techniques&Mass Spectrometry
- Supercritical Fluid Chromatography (SFC)&Atomic Spectroscopy
- Chromatographic methods for sample preparation&Molecular Spectroscopy
- Additional Methods&Structural Determination from Spectral Data

Course Outcomes

- Understand the basic principles of chromatography.
- Choose appropriate experimental strategy for research. Understand the instrumentation of modern chromatographic techniques, e.g. GC and HPLC.
- Develop a strong diversified background in modern chromatographic techniques.
- Develop critical-thinking, and problem based learning skills. Understand the basic principles of spectroscopy.

- Understand the nature electromagnetic radiations. Understand basic theories of UV, IR, Mass, NMR spectroscopic techniques
- Able to analyze and interpret spectra of UV, IR, Mass, NMR spectroscopic techniques

Recommended Reading (including Textbooks and Reference books)

- Hollas J M, 2004, *Modern Spectroscopy*, 4rth Ed. Ed., Wiley [ISBN: 0-470-84416-7]
- Kemp W 1991, *Organic Spectroscopy*, 3rd Ed. Ed., Macmillan [ISBN: 033342171X]
- Silverstain R.M., Webster F.X., Kiemle D 2004, *Spectrometric Identification of Organic Compounds*, 7th Ed. Ed., Wiley [ISBN: 0-471-39362-2]
- Colin N. Banwell, Elaine M. McCash 1994, *Fundamentals of molecular spectroscopy*, 4rth Ed. Ed., McGraw-Hill London [ISBN: 0-07-707976-0]
- Veronika R. Meyer, 2010, *Practical High-Performance Liquid Chromatography*, Wiley-Blackwell [ISBN: ISBN:978-0470682173]
- Harold M. McNair, James M. Miller, 2009, *Basic Gas Chromatography*, Wiley-Blackwell [ISBN: ISBN:0470439548]
- Judith F. Rubinson, Kenneth A. Rubinson 1998, *Contemporary chemical analysis*, Prentice Hall Upper Saddle River, NJ [ISBN: ISBN:0135193311]
- R. A. Day, Jr., A. L. Underwood 1991, *Quantitative analysis*, Prentice Hall Englewood Cliffs, N.J. [ISBN: ISBN:0137471556]
- Robert E. Ardrey, 2003, Liquid chromatography-mass spectrometry, J. Wiley, New York [ISBN: ISBN:0471498017]

EME 803 Combustion & Propulsion

Credit Hours: **3**

Pre-requisites: **Nil**

Course Objectives

- To provide a sound understanding of how to select an appropriate fuel for a given combustion application
- How to classify and recognize the properties of solid, liquid and gaseous fuels.
- To attain knowledge of the mechanisms and properties of both flames controlled by mixing as well as reaction.

- The influence of principal operating parameters on combustion efficiency, intensity, range of stability etc will also be developed via this course.

Course Contents

- Introduction to Combustion, Classification of fuels&Explosions in Closed Vessels
- The Chemistry of Combustion&Combustion of Hydrocarbons
- Flames and Combustion Waves&Detonation Waves in Gases
- Special aspects of Gaseous combustion
- Combustion in Mixed & Condensed Phases&Rocket propulsion
- Selection of propellants: SolidLiquid or hybrid & Rocket Motor Design

Course Outcomes

- After studying this course, our graduate will be better equipped to join the industry / research related jobs of chemical industry.

Recommended Reading (including Textbooks and Reference books)

- Flame & Combustion, J.A. Barnard & J.N Bradley
- Combustion, applications & its concepts, Stephen R. Turns
- Liquid Rocket Engine Combustion Instability (1995) Vigor Yang - Pennsylvania State University (Editor) William E. Anderson - Pennsylvania State University (Editor)
- Non-steady Burning and Combustion Stability of Solid Propellants (1992), Luigi De Luca Politecniceo de Malino, Edward W. Price
- Guns, Mortars & Rockets, J W Ryan (1982).

EME-810 Materials Technology

Credit Hours: **3**

Pre-requisites: **Nil**

Course Objectives

- To develop expertise in the area of structures.
- To develop understanding of properties and the processing of Materials and polymers.

Course Contents

- Materials – structure&Properties& processing
- Mechanical working of metals&Heat treatment of steels
- Precipitation hardening&Alloying for maximum fracture toughness
- Introduction to polymeric materials

Course Outcomes

- After studying this course, the students will be proficient in utilizing Materials Technology
- Apply them to the research areas related to Materials & Polymers.

Recommended Reading (including Textbooks and Reference books)

- Materials Science and Technology by John Wiley and Sons, Inc
- James A. Jacobs, Thomas F. Kilduff, Engineering materials technology, Pearson/Prentice Hall, 2005

EME 902 - Numerical Methods in Chemical Engineering

Credit Hours: **3**

Pre-requisites: **Nil**

Course Objectives

- To teach the students:
  - The type of roots.
  - The successive substitution.
  - The classification of ODEs for application in the chemical engineering.

Course Contents

- Introduction to types of roots and their approximation&TheWegstein method
- Method of successive substitution&Method of linear interpolation
- Newton Raphsonmethod&Newton's method for simultaneous non-linear equations
- Eigen value method, Matrix and vector operations&Cramer's rule
- Gauss Elimination method&Gauss-JordanReduction method
- Gauss-Seidel substitution method, Jacobi method&Symbolic operations
- Backward Finite Difference, Central Finite Difference&Forward Finite Difference

- Difference equations and their solutions&Differentiation by backward
- Finite differences&Differentiation by central finite differences
- Differentiation by forward finite differences&Integration formulas
- Newton-Cotes formulas of integration&Linear ordinary differential equations
- Classification of ordinary differential equations
- Nonlinear ordinary differential equations- initial value problems
- Nonlinear ordinary differential equations- boundary value problems
- Classification of partial differential equations&Initial and boundary conditions
- Solution of partial differential equations using finite differences
- Stability analysis&Introduction to finite element methods.

Course Outcomes

- The students will gain expertise for mathematical evaluation using the mathematical modeling
- Will learn, the numerical techniques applied in chemical engineering.

Recommended Reading (including Textbooks and Reference books)

- Advanced Engineering Mathematics, KREYSIZIG (7th Edition)
- Computational & Applied Mathematics for Engineering Analysis, ASCAKMAK

EME 921 - Momentum, Heat & Mass Transfer in Chemical Engineering Separation Processes

Credit Hours: **3**

Pre-requisites: **Nil**

Course Objectives

- To provide expertise in the area of Momentum, Heat & Mass Transfer in Chemical Engineering separation processes.
- To teach the techniques related to laws of viscosity and mechanism of momentum transport, velocity distribution in laminar flow, diffusely in mass transport.
- Ultimately, teach them thermal separation processes.

Course Contents

- Viscosity and mechanism of momentum transport
- Newton's Law of viscosity&Non-Newtonian fluids
- Temperature and pressure dependence of viscosity&Theory of viscosity of gases
- Velocity distribution in Laminar flow&Shell momentum balance
- Flow of falling film&Flow through circular tube&Flow through an annulus
- Equation of change for isothermal systems&Equation of continuity
- Equation of motionEquation of energy
- Use of equation of change for steady state flow problems
- Dimensional analysis of equation of change&Friction factor for flow in tubes/ducts
- Viscosity and mechanism of heat transport&Fourier's law of heat conduction
- Temperature and pressure dependence of thermal conductivity
- Theory of thermal conductivity of gases&liquids& solids
- Temperature distribution in Laminar flow&Shell energy balance
- Boundary conditions&Heat conduction with an electric heat source
- Nuclear heat source, A chemical heat source&Heat convection in boundary layers
- Heat conduction through composite walls&Heat convection in tubes/ducts
- Equation of change for non-isothermal systems&Equation of energy
- Energy equation for curvilinear coordinates&Unsteady heat conduction in solids
- Use of equation of change for steady state heat transfer
- Dimensional analysis of equation of change&Definition of concentration
- Heat transfer coefficient for forced convection in tubes
- Heat transfer coefficient for mixed convection in tubes
- Diffusivity and mechanism of mass transport &Velocities and mass fluxes
- Fick's law of diffusion&Temperature and pressure dependence of diffusivity
- Theory of diffusion in gases, Theory of diffusion in liquids
- Concentration distribution in Laminar flow&Shell mass balance
- Boundary conditions&Diffusion through a stagnant gas film
- Diffusion with a chemical reaction&Diffusion into a falling film liquid
- Diffusion and chemical reaction inside a porous catalyst
- Equation of change for multi-component systems

- Equation of continuity for binary mixtures&Unsteady mass diffusion
- Equation of continuity for curvilinear coordinates&Efficiency
- Use of equation of change for steady state diffusion&Trays packing
- Dimensional analysis of equation of change&Design procedures
- Mass transfer coefficient for forced convection in tubes&Hybrid systems
- Thermal separation processesDistillation&Membrane phase contactors
- Introduction, Equilibrium & equilibrium stages&Alternative distillation process
- Distillation economics, AdsorptionIntroduction&Adsorption and Desorption
- Adsorption processes, Design considerations&Membrane separation processes
- Membrane Processes&IntroductionSelectivity Flux &Driving force
- Membrane structure and materials,Membranemodules&Pore model
- Membrane separation processes, Design considerations&Fuel Cell
- Modeling heat & mass transfer in membranes&Heat transfer model
- Solution-diffusion model, Dusty gas model&Combined heat and mass transfer
- Application of membrane processes in chemical industry&Reverse osmosis
- Ultra filtration, Gas separation, Perevaporation, Ion-conducting membranes

Course Outcomes

- After studying this course student will be able to apply, the gained knowledge in the research area related to chemical engineering separation processes.

Recommended Reading (including Textbooks and Reference books)

- Transport Phenomena, R. B Bird & W.E STEWART.
- Transport Phenomena, R.S BROD KEY, & HC HERSHEY

EME 981-Advanced Fuel Technology

Credit Hours: 3

Pre-requisites: Nil

Course Objectives

- To introduce Advanced Fuel Technology in Methanol, Hydrogen and hydrazine.
- Chemical reactivity, Specification analysis, Fire hazards&storage and transportation

Course Contents

- Historical development of Methanol&Production of methanol
- Reactions and applications of methanol&Future opportunities and challenges
- Storage and handling aspects, Pure methanol&Methanol containing system
- Toxicity, Occupational health and environmental concerns&Production of methanol
- Thermodynamics and kinetics of methanol synthesis & Syngas preparation process
- Steam reforming of natural gas to methanol&Conversion of methanol to gasoline
- Conversion of methanol to olefins, Methanol fuel&Methanol as a fuel
- Methanol vehicle exhaust emissions&Future methanol engine and vehicles
- Methanol in heavy duty engines&Outlook for fuel methanol
- Hydrogen An energy dependent world&The basics of hydrogen
- History and development, Why hydrogen as a fuel&Pros and cons in to the future
- ProductionHydrogen from fossil electrolysis, Hydrogen from coal
- Hydrogen from methane&Hydrogen from Biomass pyrolysis /steam reforming
- Modeling of hydrogen separation &Storage and handling aspects
- Membrane for enhanced hydrogen production from Water
- Gas shift reaction, Hydrogen-metal systems&Mass storage of hydrogen
- Hydrogen storage for future energy systems&Fuel cell system model
- Transportation of gaseous hydrogen by pipelines&Hydrogen fuel
- Transportation of liquid hydrogen by truck or ship&Analysis and simulations
- Fuel cells, Progress in PEM fuel cell development&Hydrogen fueled transportation
- Fuel cell vehicles, Hydrazine Introduction&Physical properties of hydrazine
- Hydrazine chemistry, Production of hydrazine&Hydrazine handling aspects
- Decomposition and combustion of hydrazine&Hydrazine applications

Course Outcomes

- The graduates will be able to apply the gained knowledge in the research related projects of fuel efficiency.

Recommended Reading (including Textbooks and Reference books)

- Hydrogen power of the future, Chris Hayhurst
- Hydrogen energy system: Production, utilization and future aspects, Y. Yurum

- Methanol production and use, Wu-Hsun Cheng, H.H. Kung Advances in Hydrogen energy, G. Padro, F. Lau
- Prospectus for hydrogen and fuel cell, Control of fuel cell power systems: Principal, Modeling, Analysis and Feedback, Pukrushpau, Awa G., HueiPeng
- Hydrazine and its derivatives: Preparation, Properties, Applications, E. W. Schmidt

MSE 952 Materials for Biomedical Applications

Credit Hours: **3**

Pre-requisites: **Nil**

Course Objectives

- To develop basic level of expertise of using Materials in the Biomedical Applications for research and the industry
- Quantitative assays of cell behavior in culture&Biosensors and micro-array

Course Contents

- Surface chemistry and physics of selected metals&Polymers and ceramics
- Surface characterization methodology&Modification of biomaterials surfaces
- Bulk properties of implants and acute and chronic response to implanted biomaterials. Synthetic
- Materials for Orthopedic and Dental applications&Bio compatibility of Metallic
- Polymeric and Ceramic implants&Special Implants and Materials for Stents

Course Outcomes

- The graduates will be able to apply their knowledge in Biomedical Applications to make it more efficient in research related projects to the Biomedical Engineering & Sciences.

Recommended Reading (including Textbooks and Reference books)

- Biomaterials Science: An Introduction to Materials in Medicine, Ratner, Buddy D.
- Engineering Materials for Biomedical Applications, Hin, TeohSwee.
- Bio-Implant Interface: Improving Biomaterials and Tissue Reactions by J.E. Ellingsen and S.P. Lyngstadaas

- Bio-Based Polymers and Composites by Richard Wool and X. Susan
- Bio-Materials & Prototyping Applications in Medicine by Bopaya Bidanda and Paulo Bartolo
- Bio-Implant Interface: Improving Biomaterials and Tissue Reactions by J.E. Ellingsen and S.P. Lyngstadaas
- Bio-MEMS: Technologies and Applications by Wanjun Wang and Steven A. Soper

MSE 871 Polymer Engineering

Credit Hours: 3

Pre-requisites: Nil

Course Objectives

- To provide information related to Polymers Materials, their classification, structure and synthesis for application in the industry.
- Polymeric Materials Classification&Structure and synthesis

Course Contents

- Polymerization, Co-polymerization&Solutions and blends
- Polymerization conditions and polymers processes&Rheological properties
- Stabilization of high polymers Mechanical Properties
- Structure-property relationship&Processing and forming of polymers.
- Engineering applications of polymeric materials

Course Outcomes

- After studying this course students will be able to work in the Polymer industry and work on the research related projects.

Recommended Reading (including Textbooks and Reference books)

- Introduction to Polymers (R.J. Young and P.A. Lovell)
- Synthetic Polymers: Technology, Properties, Applications (Feldman and Barbalata)

MSE-880 Corrosion and Protection

Credit Hours: **3**

Pre-requisites: **Nil**

Course Objectives

- To teach techniques against Corrosion in the Materials and their protection.
- Protection methods, Inhibitors&Catholic and anodic protectiontechniques

Course Contents

- Electrochemical aspects of corrosion&EMF series and various corrosion cells
- Electrochemical polarization, Passivation&Types of corrosion
- Pitting and crevice corrosion, Galvanic corrosion&Stress corrosion cracking
- Cavitation and fretting, Corrosion and fatigue&Corrosion evaluation techniques
- High temperature oxidation and corrosion

Course Outcomes

- Will help the students using these techniques for protection of their products against Corrosion.

Recommended Reading (including Textbooks and Reference books)

- Handbook of corrosion engineering (Pierre R. Roberge)
- Principles and Prevention of corrosion (Denny A. Jones)
- Corrosion and Corrosion control (Herbert H. Uhlig)

CSE-801 Computational Fluid Dynamics

Credit Hours: **3**

Pre-requisites: **Nil**

Course Objectives

- Equip students with the knowledge base essential for application of computational fluid dynamics to engineering flow problems,
- Will provide the graduates essential numerical background for solving the partial differential equations governing the fluid flow,

- Will develop students' skills of using a commercial software package.

Course Contents

- What is Computational Fluid Dynamics?
- Governing Equations of Fluid Flow (Navier-Stokes Equations)
- Mathematical Behavior of Partial Differential Equations
- Finite Volume Method for Diffusion Problems
- Finite Volume Method for Convection – Diffusion Problems
- Solution algorithms for steady flows&Solution of discredited equations
- Finite Volume method for unsteady flows
- Implementation of boundary conditions and Errors and uncertainty in CFD Modeling.

Course Outcomes

- Understand solution of aerodynamic flows.
- Appraise & compare current CFD software.
- Simplify flow problems and solve them exactly.
- Define and setup flow problem properly within CFD context.
- Performing solid modeling using CAD package and producing grids via meshing tool.
- Understand both flow physics and mathematical properties of governing Navier-Stokes equations and define proper boundary conditions for solution.
- Use CFD software to model relevant engineering flow problems.
- Will be able to analyze the CFD results. Compare with available data, and discuss the findings.

Recommended Reading (including Textbooks and Reference books)

- H. Versteeg and W. Malalasekra, An Introduction to Computational Fluid Dynamics: The Finite Volume Method, 2007.
- J.D. Anderson, Jr., Computational Fluid Dynamics: The Basic with Applications, McGraw Hill, Inc., 1995.
- J.C. Tannehil, D.A. Anderson, and R.H. Pletcher, Computational Fluid Mechanics and Heat Transfer , 2nd Edition, Taylor & Francis, 1997, ISBN 1-56032-046-X.
- Suhas V. Patankar, Numerical Heat Transfer and Fluid Flow, Taylor & Francis, 1980.