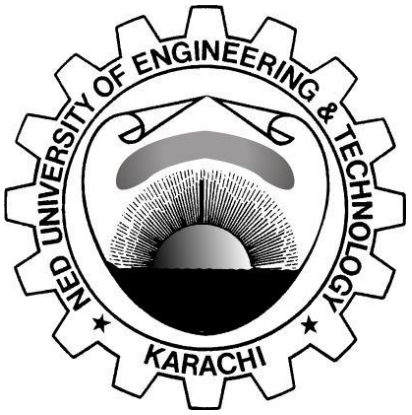
DEPARTMENT OF POLYMER AND PETROCHEMMICAL ENGINEERING



SEMESTER

SYLLABI OF COURSES

FOR

M.ENGG. (POLYMER ENGINEERING) PROGRAMME

NED UNIVERSITY OF ENGINEERING & TECHNOLOGY, KARACHI-75270

PAKISTAN

Compulsory and elective courses for M. Engg. (Polymer Engineering)

Compulsory Courses:	**Credit hours**
PP-511: Mathematical Methods in Polymer Engineering	3
PP-512: Advanced Polymer Processing	3
PP-513: Polymer Reactor Engineering	3
PP-514: Rheology of Complex Fluids	3
PP-515: Polymer Structure-Property Relationships	3

Elective Courses:

PP-525: Advanced Polymer Composites	3
PP-526: Fibre Technology	3
PP-527: Polymer Adhesives and Coatings	3
PP-528: Polymer Product Design	3
PP-529: Specialty and Functional Polymer Materials	3
PP-530: Rubber Technology	3
PP-532: Polymer Degradation, Stability and Recycling	3
PP-531: Polymer Characterization	3
ME-530: Project Management	3
PP-600: Independent Study project	6

PP-601: Dissertation 9

PP-401: Introduction to Polymeric Materials NC

Compulsory Courses

PP-511: Mathematical Methods in Polymer Engineering

Linear Algebra: Algebra of matrices, inverse, rank, system of linear equations, symmetric, skew-symmetric and orthogonal matrices, Hermitian, skew-Hermitian, unitary matrices, eigenvalues and eigenvectors, diagonalisation of matrices, Cayley-Hamilton Theorem.

Vector Calculus: Gradient, divergence and curl, vector Identities, directional derivatives, line, surface and volume integrals, Stokes, Gauss and Green's theorems applications.

Tensors: Tensor operations, vector operations using index notation, principal axes for Cartesian tensors, maximum shear stresses

Differential equations and partial differential equations: Gamma functions, Bessel Functions, Legendre Functions, solutions to partial differential equations and orthogonal functions.

Advanced numerical methods: Brief review of numerical methods, finite difference methods for solution of field problems, grid generation, solution of initial value problem/boundary value problem with / without free, moving or periodic boundaries, solution of stiff/coupled equations, finite element and volume methods.

References:

1. Mathematical Methods for Physics and Engineers, 3rd Ed., Riley K.F., Hobson M.P., Bence S.J., Cambridge University Press, 2006

2. A Concise Handbook of Mathematics, Physics, and Engineering Sciences, Polyanin A.D., Chernoutsan A.I., Taylor & Francis Group, 2011

3. Modern Advanced Mathematics for Engineers, Mitin V. V., Romanov D.A. and Polis M.P., John Wiley and Sons, 2001

6. Numerical Methods for Engineers, 6th Ed., Chapra S.C., Canale R.P., McGraw-Hill, 2010

7. Applied Mathematics and Modeling for Chemical Engineers, 2nd Ed., Rice R. G., DO D. D., Wiley, 2012

PP-512: Advanced Polymer Processing

Principles of Polymer Processing: Polymer melt flow in channels and cavities, Modelling and analysis of various polymer processing operations, (e.g. extrusion, injection molding, blow molding, thermoforming, compression molding and fiber spinning).

Processing of biaxially oriented polyethylene terephthalate (BOPET), biaxially oriented polypropylene (BOPP) and cast polypropylene (CPP) films.

Reactive Polymer Processing: Polymer chain modification, basic principles and equipment, examples of multicomponent immiscible and compatibilized immiscible polymer systems.

References:

1. Polymer Extrusion, 1st Ed., Lafleur P.G., Vergnes B., Wiley, 2014

2. Handbook of Plastics Technologies: The Complete Guide to Properties and Performance, 2nd Ed., Harper C., McGraw-Hill, 2006

3. Plastics Additives and Testing, 1st Ed., Subramanian M.N., Wiley, 2013

4. Understanding Plastics Testing, Hylton D.C., Hanser Gardner, 2004

5. Extrusion of Plastics: Theory and Practice, Chung C.I., Hansen Gardner, 2000

6. Polymer Processing: Principles and Design, 2nd Ed., Baird D.G., Collias D.I., Wiley, 2014

7. Principles of Polymer Processing, 2nd Ed., Tadmor Z. and Gogos C.G. Wiley, 2006

8. Plastics: Materials and Processing, 3rd Ed., Strong A.B., Prentice Hall, 2005

9. Plastics Testing and Characterization: Industrial Applications, Naranjo A., Noriega M.P., Osswald T., Roldan-Alzate A., Sierra J.D., Hanser, 2008

PP-513: Polymer Reactor Engineering

Introduction to Polymerization: Classes of polymerization, polymerization techniques, examples of some commercial polymers, polymerization reactors.

Principles of Polymer Reaction Engineering: Polymerization kinetics for step growth and chain growth mechanism under ideal and real conditions.

Industrial Polymerization Reactors: Reactor classifications, key design issues, design considerations for homopolymers and random copolymers, polymerizations in a suspending phase.

Reactor Scale-up, Analysis and Modeling: Fundamental design equations of polymerization reactors, scale-up of commonly use industrial reactors, comprehensive process models.

Case studies of some important industrial polymerization reactions.

References:

1. Principles of Polymerization, 4th Ed., Odian G., Wiley, 2004
2. Polymer Reaction Engineering, 1st Ed., Asua J., Wiley, 2007
3. Handbook of Polymer Reaction Engineering, 1st Ed., Meyer T., Keurentjes J., Wiley, 2005
4. Polyolefin Reaction Engineering, 1st Ed., Soares J.B.P., McKenna T.F.L., Wiley, 2012
5. Fundamentals of Polymer Engineering, 2nd Ed., Kumar A., Gupta R.K., CRC Press, 2003
6. Handbook of Polymer Synthesis, 2nd Ed., Kricheldorf H.R., Nuyken O., Swift G., CRC Press, 2004
7. Reaction Engineering of Step Growth Polymerization, 1st Ed. (re-print), Gupta S.K., Kumar A., Springer, 2013
8. Polymerization Process Modeling, Datson N.A., Galvan R, Laurence R.L, Tirrel M., Wiley, 1995
9. Polymer Reactor Engineering, McGreavy C., Springer, 2012

PP-514: Rheology of Complex Fluids

Rheological Principals: Classifications of fluids behavior

Viscoelasticity: Linear viscoelasticity, viscoelastic models, relaxation spectrum, methods of measurement, (static and dynamic methods), time-temperature superposition.

Introduction to Non-linear Viscoelasticity: Nonlinear phenomena, simple non-linear rheological models

Parameters Influencing Polymer Rheology: Factors affecting flow behavior (e.g. temperature, molecular weight distribution, additives, blend composition and morphology etc.)

The Role of Rheology in Polymer Processing: Melt flow index, flow analysis using rheological models, extensional viscosity and melt strength, rheological problems in co-extrusion (layer-to-layer non- uniformity, interfacial instability, trouble-shooting with the help of rheology.

Rheometry: Viscometers and rheometers.

References:

1. Non-Newtonian Flow and Applied Rheology, 2nd Ed., Chhabra R.P. and Richardson J.F.; Butterworth-Heinemann, 2008
2. Rheology: Principles, Measurements and Applications, Macosko C.W.; Wiley-VCH, 1994
3. Viscoelastic Properties of Polymers, 41st Ed., Ferry J.D., Isha Books, 2013
4. Engineering Rheology, 2nd Ed., Tanner R.I., Oxford University Press, 2000
5. Understanding Rheology, Morrison F.A., Oxford University Press, 2001

6. Introduction to Polymer Viscoelasticity, 1st Ed., Shaw M.T., Wiley, 2013
7. Applied Polymer Rheology, Kontopoulou M., Wiley, 2012

PP-515: Polymer Structure-Property Relationships

Polymer properties affected by their chemical composition and molecular architecture. Polymer Structures/Morphology: Morphology-processing-property relationships (e.g. injection, blow molding, rotational molding etc.), deformation mechanisms and orientation, study of spherulites; thermodynamics and kinetic forces affecting polymer crystallization, physical techniques for studying crystal structure and morphology of polymers.

Effect of Orientation and Crystallinity on Polymer Properties: Orientation in polymers (shear and tensile deformations).

Molecular and structural requirements of polymers for formation of films, fibers and multiphase systems.

References:

1. Properties of Polymers: their correlations with chemical structure: their numerical estimation and prediction from additive group contributions, 4th Ed., van Krevelen D.W., te Nijenhuis K., Elsevier, 2009
2. Polymeric Materials: Structure, Properties, Applications, Ehrenstein G., Hanser Publication, 2001
3. Crystallization of Polymers: Volume 1, Equilibrium Concepts, 2nd Ed., Mandelkern L., Cambridge University Press, 2011
4. Crystallization of Polymers: Volume 2, Kinetics and Mechanisms, 2nd Ed., Mandelkern L., Cambridge University Press, 2012
5. Mechanical Properties of Solid Polymers, 3rd Ed., Ward I.M., Sweeney J., Wiley 2012
6. Structure and Properties of oriented Polymers, 2nd ed., Ward I.M., Springer, 1997
7. Polymers: Structure and Properties, 1st Ed., Daniels C.A., CRC Press, 1989

Elective Courses

PP-525: Advanced Polymer Composites

Overview of polymer composites and their fabrication.

Factors influencing on performance of composites, structure - property relationship.

Advanced mechanics of composites, classical lamination theory, analysis and failure of reinforced composite material systems, anisotropic elasticity, stress analysis and design of laminated composites including 3D effects, stress concentrations, free-edge effects, hygrothermal behavior, adhesive and mechanical connections.

Polymer Nanocomposites: Comparison with conventional composites, matrix materials and nano-particulates, challenges in the production polymer nanocomposites, characterization, applications and future trends.

References:

1. Fiber Reinforced Composites, Mallick P.K., Marcel Dekker, 3rd Ed., 2007

2. Reinforced Plastics: Properties and Applications, Seymour R.B., ASM Int., 1991

3. Mechanics of Composite Materials, Kaw A.K., Taylor & Francis, 2nd Ed., 2005

4. Polymer Composites: From Nano-to-Macro-Scale, Friedrich K., Fakirov S., Zhang Z., Springer, 2005

5. Polymer nanocomposites, Mai Y-W., Yu Z-Z., CRC Press, 2006

6. Characterization Techniques for Polymer Nanocomposites, Mittal V., Wiley-VCH, 2012

PP-526: Fiber Technology

Introduction: Raw materials and techniques used to produce fibers.

Structural Principles of Polymeric Fibers: Orientation, crystallinity and morphology. Theory of Polymeric Fiber Spinning: Chemistry of important fiber forming polymers, thermodynamics of spinning, rheology and heat transport in spinning, effect of spinning parameters on fiber structure.

Post-Spinning Operations: Drawing and heat-setting in thermoplastic fiber, effect of various parameters on structure and properties of fiber.

Solution (Gel) Spinning: Comparison of solution spinning with other conventional spinning techniques, effect of dope quality and spinning parameters on solution spinning, solution spinning applications.

Electro-Spinning: Effects of various parameters on electro-spinning, electro-spinning applications.

Characterization of Fibers: Fiber density, optical and electron microscopy, thermal analysis, tensile properties, crystallinity and orientation.

References:

1. Fundamentals of Fiber Formation: the Science of Fiber Spinning and Drawing, Ziabicki A, Wiley, 1976

2. High-Speed Fiber Spinning, Ziabicki A., Kawai H., Krieger Publishing Company, 1985

3. Structure Formation in Polymeric Fibers, Salem D.R., Hanser Verlag, 2001

4. Advanced Fiber Spinning Technology, Nakajima T., Woodhead Pub., 1994

3. Manufactured Fibre Technology, Gupta V.B., Kothari V.K., Chapman & Hall, 1997

4. Handbook of Textile Fibres Vol. II-Manmade fibers, Cook J.G., Woodhead Pub., 2001

5-Fibre Science and Technology, Kostikov V.I., Chapman & Hall, 1995

PP-527: Polymer Adhesives and Coatings

Formulation of Modern Coatings: Raw materials and polymers systems, selection of components.

Film Formation: Theories of film formation, cross-linking, film defects, solvent evaporation, particle size effects.

Types of Coatings: Solvent/water-borne, powder, radiation cure and architectural coatings, smart coatings, nano-coatings.

Coating Application: Thermodynamics of interfaces, theories of application methods, substrate pre-treatment, adhesion, barrier properties, durability, corrosion protection, hiding and opacity, degradation of coatings.

Regulatory considerations, volatile organic contents (VOC's).

Adhesives: Adhesion theories, raw materials, compounding, substrate pre-treatment, adhesive selection, solvent and water based adhesives, bond strength, failure mechanisms.

References:

1. Coatings Materials and Surface Coatings, Tracton, A.A., CRC Press, 2006
2. Adhesives and Coatings Technology, Ghosh P., Tata McGraw-Hill , 2008
3. Principles of Surface Coating Technology, Parker D.H., Interscience Publishers, 2004
4. Surface Coatings: Science and Technology, Paul S., John Wiley, 2nd Ed., 1996
5. High-Performance Organic Coatings, Khanna, A.S., Elsevier, 2008

PP-528: Polymer Product Design

Product Design: Effect of polymeric materials and its processing on product design, design methods considering fracture behavior and deformation data.

Design products based on different processing methods, welding, mechanical assembly, adhesive, and other fastening methods.

Computer Aided Engineering (CAE): Flow analysis software, finite element and volume analysis, modeling and meshing for computer simulation.

Cost Analysis: Part cost based on material(s), process method and number of parts required, product development methodology and tools.

References:

1. Plastics Product Design, Beck R.D., Van Nostrand Reinhold Co., 1980

2. Plastic Product Design Engineering Handbook, Levy S., DuBois J.H., Chapman and Hall, 1984

3. Plastics Engineered Product Design, Rosato D., Rosato D.V., Elsevier, 2003

4. Flow Analysis of Injection Molds, Kennedy P.K., Zheng R., Hanser Pub., 2nd Ed., 2013

5. Plastics Materials: Properties and Applications, Birley A.W. Springer, 2nd Ed., 2013

6. Industrial Design of Plastic Products, Gordon M.J., Wiley-Interscience, 2003

7. Plastic Component Design, Campbell P.D.Q., Industrial Press, 1st Ed., 1996

8. Plastics Engineering, Crawford R.J., Elsevier, 3rd Ed., 1998

PP-529: Specialty and Functional Polymer Materials

Liquid crystalline polymers, electrically conducting polymers, heat resistant polymers, polymeric membranes, polymers in biomedical engineering and their applications.

Ionic polymers: Ionomers, ionic cross linking, ion-exchange, ionic polymer-metal composites, applications.

Polymers in textile finishing: Thickeners, binders, functional finishes, anti-microbial coatings, water-repellent and flame-retardant coatings.

Polymers in construction and agriculture: Polymers for concrete reinforcement, polymer as thermal insulators, hydrogels and water absorbing polymers, polymer encapsulation of pesticides.

References:

1. Liquid Crystalline Polymers, Donald A. M., Windle A. H., Hanna, S., Cambridge University Press, 2006

2. Engineering and Specialty Thermoplastics: Water Soluble Polymers, Fink J.K., Wiley & Sons, 2011

3. Polymers for High Technology: Electronics and Photonics, Bowden M.J., Turner S.R. ,Books on Demand, 1987

4. Synthetic polymeric membranes: a structural perspective, Kesting R.E., Wiley, 1985

5. Biopolymers: Biomedical and Environmental Applications, Kalia S., Avérou L., Wiley & Sons, 2011

6. Developments in ionic polymers, Vol. 1, Wilson A.D., Prosser H.J., Applied Science Pub., 2013

7. Polymers in Construction, Akovali G., iSmithers Rapra Press, 2005

8. Agricultural and synthetic polymers: biodegradability and utilization, Glass J.E., Swift G., American Chemical Society, 1990

9. Degradable Polymers: Principles and Applications, Scott G., Springer, 2nd Ed., 2003

PP-530: Rubber Technology

Molecular basis for material to act as a rubber, rubber elasticity

Material Properties and Selection: Effects of molecular structure of natural and synthetic rubbers.

Compounding and vulcanization: Role of additives, processing and product manufacture.

Environmental and chemical resistance: Degradation of rubber compounds and methods of protection.

Manufacturing techniques: Tires, belting, rubber to metal bonded components,

Testing of raw materials, vulcanizates, and finished products as per international standards and service performance requirements.

Thermoplastic Elastomers: Classification and applications.

Rubber-Clay Nanocomposites: Synthesis, characterization and applications.

Recycling and re-use of waste rubber

References:

1. The Science and Technology of Rubber, Mark J.E., Erman B., Roland M., Academic Press, 4th Ed., 2013

2. Rubber Processing Technology, Materials and Principles, White J.L., Hanser Verlag, 1995

3. Engineering with Rubbers: How to Design Rubber Components, Gent A.N., Hanser Verlag, 2nd Ed., 2001

4. Rubber Technology: Compounding and Testing for Performance, Dick J.S., Hanse Verlag, 2001

5. Thermoplastics Elastomers, Holden G., Kricheldorf, H.R., Quirk R.P., Hanse Verlag, 3rd Ed., 2004

6. Rubber Compounding: Chemistry and Applications, Rodgers B., Taylor & Francis, 2004

7. Rubber-Clay Nanocomposites: Science, Technology, and Applications, Galimberti M., John Wiley & Sons, 2011

PP-532: Polymer Degradation, Stability and Recycling

Polymer Degradation: Chemical and physical factors affecting degradations, classification of degradation processes (thermal, photochemical, oxidative and biodegradation), effects of degradation on polymer properties.

Polymer Stabilization: Classification and mechanisms of stabilization.

Polymer Recycling: Review of various commercial grades of plastics made from recycled sources, existing technologies for recycling, energy recovery.

Case studies of some industrially important plastics and rubber products.

Global and local regulations for polymer recycling.

References:

1. Polymers and the Environment, Scott G., The Royal Society of Chemistry, 1999

2. Degradable Polymers: Principles and Applications, Scott G., Kluwer Academic Press, 2nd Ed., 2003

3. Atmospheric oxidation and antioxidants Vol. 2, 2nd Ed., Scott G., Elsevier, 1993

4. Thermal Stability of Polymers, Crompton T.R., iSmithers Rapra Technology, 2012

5. Thermal Degradation of Polymeric Materials, Pielichowski K., Njuguna J., Smithers Rapra Press, 2008

6. Polymer Photodegradation: Mechanisms and Experimental Methods, Rabek J.F., Chapman & Hall, 1995

7. Introduction to Plastics Recycling, Goodship V., iSmithers Rapra Technology, 2nd Ed., 2007

8. Polymer Recycling: Science, Technology and Applications, Scheirs J., John Wiley & Sons, 1998

9. Plastics Recycling: Products and Processes, Ehrig R.J., Hanser Gardner Publications, 1992

PP-531: Polymer Characterization

Introduction and significance of polymer characterisation for property determination.

Molecular weight determination: Gel permeation chromatography (GPC), light scattering and viscometry.

Molecular spectroscopy: Overview, UV and visible spectroscopy, vibrational spectroscopy, and nuclear magnetic resonance (NMR).

Thermal Characterization: Differential scanning calorimetry (DSC), thermogravimetric analysis (TGA), dynamic mechanical thermal analysis (DMTA).

Microscopy: Optical and electron microscopy

X-ray Diffraction: Wide angle and small angle X-ray diffraction.

Rheometry: Viscometers and rheometers.

Mechanical characterization: Mechanical testing of polymers (tensile testing, compression testing, 3-point and 4-point bending testing, creep and stress relaxation test, impact test, micro and macro hardness testing).

References:

1. Characterization and Analysis of Polymers, Seidel A., Wiley, 2008.
2. Thermal Analysis of Polymers: Fundamentals and Applications, Menczel J.D. Prime R.B., Wiley, 2009
3. Electron Microscopy of Polymers, Michler G.H., Springer, 2008.
4. Polymer Characterization Techniques and Their Application to Blends, Simon G.P., American Chemical Society, 2003.
5. Polymer Analysis, Stuart B.H., John-Wiley & Sons, 2002.
6. Polymer Characterization: Physical Techniques, 2nd Ed., Campbell D., Pethrick R.A., White J.R., Stanley Thornes (Publishers) Ltd., 2000.
7. Polymer Characterization, Brostow W., Wiley, 1999.
8. Polymer Synthesis and Characterization: A laboratory manual, Sandler S.R., Karo W. Bonesteel J-A, Pearce A.M., Academic Press, 1998.

Non Credit Course

PP-401: Introduction to Polymeric Materials

Basic concepts in polymer science and engineering, Molecular weight, molecular weight distribution and its determination, Polymer synthesis, Kinetics and mechanism of polymerization processes, Crystallization in polymers and methods of its determination, Polymer mechanical & thermal properties and their determination, Polymer Processing.

References

1. Fundamental Principles of Polymeric Materials, 3rd Ed., Brazel C.S., Rosen S.L., John Wiley & sons, 2012
2. The Elements of Polymer Science and Engineering, 3rd Ed., Rudin A., Choi P., Academic Press, 2012
3. Introduction to Polymers, 3rd Ed., Young R.J., Lovell P.A., CRC Press, 2011
4. Principles of Polymerization, 4th Ed., Odian G., Wiley, 2004
5. Fundamentals of Polymer Engineering, 2nd Ed., Kumar A., Gupta R.K., CRC Press, 2003