

Course Description

Polymer Engineering (B.Sc.)

The total number of credits (units) for this program is 141, as listed below:

General Courses: 21 Credits

Basic Courses: 35 Credits

Main Courses: 41 Credits

Specialized Courses: 40 Credits

Specialized Elective Courses: 4-9 Credits

Practical Training (does not count in total credits and GPA) 1 Credit

Each theoretical credit equals to 16 hours of education.

Each experimental credit equals to 32 or 48 hours of education.

Practical Training includes 320 hours of training activity at industries.

General Courses

Persian Language (Credits: 3, Theoretical), Islamic Knowledge I (Credits: 2, Theoretical), Islamic Knowledge II (Credits: 2, Theoretical), History of Islam (Credits: 2, Theoretical), Islamic Education & Ethics (Credits: 2, Theoretical), English Language (Credits: 3, Theoretical), Population & Birth Control (Credits: 1, Theoretical), Islamic Texts (Credits: 2, Theoretical), Islamic Revolution & Its Origin (Credits: 2, Theoretical), Physical Education I (Credits: 1, Experimental), Physical Education II (Credits: 1, Experimental)



Polymer Engineering Basic Courses

❖ Calculus I (Credits: 3 - Theoretical)

Main Topics: Differential & integral calculus, applications of integration, the relation between integration and differentiation, continuous functions, the logarithm, the exponential, and the inverse trigonometric functions, sequences, infinite series, improper integrals, polynomial approximations to functions, complex numbers.

❖ Calculus II (Credits: 3 - Theoretical)

Main Topics: Linear spaces, linear transformations and matrices, determinants, eigenvalues and eigenvectors, nonlinear analysis: differential calculus of scalar and vector fields, applications of the differential calculus, line integrals, multiple integrals, surface integrals.

❖ Differential Equations (Credits: 3 - Theoretical)

Main Topics: First order differential equations, second order linear equations, higher order linear equations, series solutions of second order linear equations, the Laplace transform, systems of first order linear equations.

❖ Engineering Mathematics (Credits: 3 - Theoretical)

Main Topics: Fourier series, integrals, and transforms, partial differential equations (pdes), complex numbers and functions, complex integration, power series, Taylor series, residue integration, conformal mapping.

❖ Numerical Computation (Credits: 2 - Theoretical)

Main Topics: Error analysis, interpolation & extrapolation, finding roots of equations with different methods, numerical differentiation and integration, finite differences, numerical methods



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for solving ordinary differential equations, matrices operations and approximating eigenvalues, numerical solutions of linear & nonlinear systems of equations, least square method.

❖ Physics I (Credits: 3 - Theoretical)

Main Topics: Part one – mechanics: vectors, motion along a straight line, motion in two and three dimensions, kinetic energy and work, rolling, torque, and angular momentum, oscillations / Part two – thermodynamics: temperature, heat, and the first law of thermodynamics, entropy and the second law of thermodynamics.

❖ Physics II (Credits: 3 - Theoretical)

Main Topics: Electric charge, electric fields, gauss' law, electric potential, capacitance, current and resistance, circuits, magnetic fields magnetic fields due to currents induction and inductance magnetism of matter; maxwell's equation electromagnetic oscillations and alternating current.

❖ Physics I Lab. (Credits: 1 - Experimental)

This course is in companion with Physics I.

❖ Chemical Engineering General Chemistry I (Credits: 3 - Theoretical)

Main Topics: Atoms, molecules, chemical bonds, liquids and solids, solutions, acids and bases, ion equilibria, oxidation and reduction, chemical reaction kinetics.

❖ General Chemistry Lab. (Credits: 1, Experimental)

This course is in companion with General Chemistry I.

❖ Analytical Chemistry (Credits: 3 - Theoretical)

Main Topics: General concepts (solvent and solutions, electrolyte dissociation, equilibriums, etc.) acids and bases titrating, oxidation/reduction titrations, complex-forming titrations, electrochemical methods, potentiometry, polarography, amperometry.



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❖ Analytical Chemistry Lab. (Credits: 1 - Experimental)

This course is in companion with Analytical Chemistry.

❖ Industrial Drawing (Credits: 2 - Theoretical-Experimental)

Main Topics: Basics, multi-view drawings, sectional views, auxiliary views, descriptive geometry, patterns and developments, dimensioning and notation, engineering visualization (AutoCAD).

❖ Computer Programming (Credits: 3 - Theoretical)

Advanced Programming using C++ language syntax.

❖ General Workshop (Credits: 1 - Experimental)

Carpentry and ironwork operations including rasping, turning, welding, etc.

Polymer Engineering Main Courses:

❖ Polymer Engineering Organic Chemistry (Credits: 3 - Theoretical)

Main Topics: General topics about alkanes, alkenes, alkynes, aromatics, halides, organometallic compounds, spectroscopy: infrared, raman, ultraviolet, nuclear magnetic resonance, mass chemical structure, nomenclature, physical, chemical and spectrum properties and main use of: alcohols, phenols, ethers, thiols, aldehydes, ketones, carboxylic acids, esters, amides etc. and Polymers and polymerization principles.

References:

- 1- L. G. Wade, Organic Chemistry, 6th Ed, Prentice-Hall, 2006.
- 2- R. Morrison, R. N. Boyd, Organic Chemistry, 6th Ed, Prentice Hall, 1992.
- 3- J. McMurry, Organic Chemistry, 5th Ed, Brooks Coles, 2011.
- 4- A. Streitwieser, C. H. Heathcock, Introduction to Organic Chemistry, McMilan, 1989.



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5- K. P. C. Vollhardt, Organic Chemistry, 5th Ed, McMilan, 2010.

❖ Organic Chemistry Lab. (Credits: 1 - Experimental)

This course is in companion with Organic Chemistry.

❖ Statics & Strength of Material (Credits: 3 - Theoretical)

Main Topics: Force systems, equilibrium, structures, distributed forces, concept of stress, stress and strain, axial loading, torsion, pure bending, etc.

References:

- 1- Engineering Mechanics Statics, Meriam & Kraige; 6th edition (2007).
- 2- Vector Mechanics for Engineers – Statics, Beer & Johnston; 7th edition (2004).
- 3- Mechanics of materials, Beer & Johnston; Third edition (2006).

❖ Material & Energy Balances (Credits: 4 - Theoretical)

Main Topics:

1. Basics: Dimensions, Units, and Their Conversion, Moles, Density, and Concentration, etc.
2. Introduction to material balances: material balance problems with and without reaction, recycle, bypass, purge, etc.
3. Gases, vapors, liquids, and solids: the ideal gas law, real gases equations of state, partial pressure, humidity, saturation, condensation, vaporization, vapor-liquid equilibria, etc.
4. Energy balances: concepts and units, heat capacity, enthalpy of formation, enthalpy of reaction, ideal processes, efficiency, the mechanical energy balance, heats of solution and mixing.
5. Simultaneous mass and energy balance for steady state systems.

References:

- 1-Elementary Principles of Chemical processes- R.M. Felder & R.W.Rousseau, Wiley, 2000
- 2- Calculus in In Industry Chemistry, Horvath, Ari.L .Wiley, 1996
- 3- Basic Principle and Calculations in Chemical Engineering, Himmelblau D., 2004
- 4- Chemical Engineering, Cremer, Herbert W., 2004



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❖ Chemical Engineering Thermodynamics I (Credits: 3 - Theoretical)

Main Topics: Introduction the first law and other basic concepts, volumetric properties of pure fluids, heat effects, the second and third laws of thermodynamics, thermodynamic properties of fluids

References:

- 1- Introduction to Chemical Engineering Thermodynamics, Seventh edition 2005
J.M. Smith, H.C. Van Ness, M.M. Abbott
- 2- Thermodynamics, An Engineering Approach, Sixth edition 2007, Yunus A. Cengel, Michael A. Boles

❖ Chemical Engineering Thermodynamics II (Credits: 3, Theoretical)

Main Topics: Homogenous solution thermodynamics, topics in phase equilibria, chemical-reaction equilibria, thermodynamics of flow processes, production of power from heat, refrigeration and liquefaction

References:

- 1- Introduction to Chemical Engineering Thermodynamics, Seventh edition 2005
J.M. Smith, H.C. Van Ness, M.M. Abbott
- 2- Thermodynamics, An Engineering Approach, Sixth edition 2007, Yunus A. Cengel, Michael A. Boles

❖ Fluid Mechanics I (Credits: 3 - Theoretical)

Main Topics: Fundamental concepts, fluid statics, fluid flow in pipes, dimensional analysis, differential and integral analysis for fluid motion, fluid machinery.

❖ Fluid Mechanics Lab. (Credits: 1 - Experimental)

This course is in companion with Fluid Mechanics.

❖ Heat Transfer I (Credits: 3 - Theoretical)



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Main Topics: Introduction steady-state conduction, one dimension steady-state conduction, multiple dimensions unsteady-state conduction, principles of convection, empirical and practical relations for forced-convection, heat transfer natural convection systems.

❖ **Heat Transfer II** (Credits: 3 - Theoretical)

Main Topics: Radiation heat transfer, condensation and boiling heat transfer, combination of conduction, convection and radiation heat transfer and its applications, heat exchangers - basics, design of heat exchangers, fuels and furnaces.

❖ **Heat Transfer Lab.** (Credits: 1- Experimental)

This course is in companion with Heat Transfer.

❖ **Mass Transfer** (Credits: 3 - Theoretical)

Main Topics: Mass transfer operations, mass transfer fundamentals, molecular diffusion in fluids, mass transfer coefficients, formulation of mass transfer models, convective mass transfer, absorption, cooling towers.

❖ **Unit Operations I** (Credits: 3 - Theoretical)

Main Topics: Distillation, liquid extraction, leaching (liquid-solid extraction).

❖ **Unit Operations II** (Credits: 3 - Theoretical)

Main Topics: Evaporation, humidification, adsorption, drying, crystallization

❖ **Unit Operations Lab.** (Credits: 1- Experimental)

This course is in companion with Unit Operations.

❖ **Kinetics and Reactor Design** (Credits: 4 - Theoretical)

Main Topics: Overview of chemical reaction engineering, homogeneous reactions in ideal reactors, kinetics of homogeneous reactions, interpretation of batch reactor data, introduction to reactor



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design, ideal reactors for a single reaction, design for single reactions, design for parallel reactions, potpourri of multiple reactions, temperature and pressure effects.

References:

- 1- Levenspiel O. "Chemical Reaction Engineering", 3rd ed., McGraw-Hill, 1999
- 2- Fogler H.S. "Elements of Chemical Reaction Engineering", 4rd ed., Printice Hall, 2005.
- 3- Missen R.W., Mims C.A. and Saville B.A. "Introduction to Chemcial Reaction Engineering and Kinetics", John Wiley, 1999.
- 4- Smith J.S. "Chemcial Engineering Kinetics", McGraw-Hill, 1983

❖ Plant Design and Economics (Credits: 3 - Theoretical)

Main Topics: Chemical engineering plant design, general design considerations, process design development, analysis of cost estimation, interest, time value of money, taxes, and fixed charges, profitability, alternative investments, and replacements, optimum design and design strategy, materials and fabrication selection, written and oral design reports, materials-handling equipment - design and costs, reactor equipment - design and costs, heat-transfer equipment - design and costs, separation equipment - design and costs.

❖ Process Control (Credits: 3 - Theoretical)

Main Topics: Review of Laplace transform, transfer functions and block diagrams, response of first-order systems, response of first-order systems in series, second-order systems and transportation lag, linear closed-loop systems, controllers and final control elements, stability, root locus, Routh method for analyzing stability, Bode method for frequency response characteristics, Nyquist method.

❖ Application of Math in Polymer Engineering (Credits: 3 - Theoretical)

Main Topics: Mathematical modeling, integral formulation, ordinary differential equations, differential formulation, Bessel differential equation, partial differential equations, numerical methods for interpolation, differentiation, integration, systems of linear equations, nonlinear algebraic equations, ODEs and PDEs.



Specialized Courses:

❖ **Chemistry and Kinetics of Polymerization** (Credits: 3 - Theoretical)

Main Topics: General properties of polymerization reactions (classification of polymer synthesis reactions), chain polymerization reactions, kinetics and thermodynamics of radical and ionic polymerization (anionic and cationic), condensation reactions, crosslinking theories, molecular weight distribution, regular polymerization and their characteristics (vinyl monomers, diene monomers, epoxides and poly-sulfides), co-polymerization.

❖ **Chemistry and Kinetics of Polymerization Lab.** (Credits: 1, Experimental)

This course is in companion with Chemistry and Kinetics of Polymerization.

❖ **Physical Chemistry of Polymers** (Credits: 3, Theoretical)

Main Topics: Fundamentals of polymer science (polymers behavior, molecular weight and its distribution, phase change, crosslinking and additives), molecular engineering (substructure and structure), molecular weight and chains size (affecting solubility, surface tension and etc.), concentrated solutions and phase diagrams, glass transition theories, polymer melting and its thermodynamics, methods of determining structure of crystals, crystalline polymer structures, methods of determining crystallinity percentage, viscoelasticity and its thermodynamic equations, swelling, stress relaxation, aging, tensile test and creep.

References:

1. N. Mohamadi, "Physical Chemistry of Polymers", Polytechnic university of Amirkabir, 2008.
2. L. H. Sperling, "Introduction to Physical Polymer Science", 4th ed. John Wiley, New York, 2006.
3. A. Tager; "Physical Chemistry of Polymers", Mir, Moscow, 1978.
4. S. F. Sun, "Physical Chemistry of Macromolecules", John Wiley, New York, 2004.
5. G Strobel; "The Physics of Polymers", Springer, New York, 1997.

❖ **Physical Chemistry of Polymers Lab.** (Credits: 1, Experimental)

This course is in companion with Physical Chemistry of Polymers.



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❖ Physical and Mechanical Properties of Polymers (Credits: 3, Theoretical)

Main Topics: This course takes a quantitative approach to the mechanical properties of polymer systems with emphasis on glass transition theories, methods of determining glass transition temperature, crystallization and its theories and mechanisms, effect of conditions on crystallization and polymer properties, different tests used for determining the properties of polymers, loss parameter and its equations, Maxwell model and its equations, modulus, different things and conditions that affects polymer properties.

References:

1. *Physical and Mechanical properties of Polymers*, L. Nielsen, R. Landel, 1993, Dekker
2. *An introduction to the mechanical properties of solid polymers*, I. Ward, J. Sweeney
3. *Mechanical Properties Of High-Impact Polymers*, C.B. Bucknal,

❖ Physical and Mechanical Properties of Polymers Lab. (Credits: 1, Experimental)

This course is in companion with Physical and Mechanical Properties of Polymers.

❖ Polymer Characterization (Credits: 3, Theoretical)

Main Topics: Major instrumental methods for identifying polymers and determining polymer molecular weight, molecular weight distribution, stereochemistry, sequence distribution in copolymers, transition temperatures, surface features, etc. The unit includes examples of the use of chemical analysis, colligative properties, chromatographic techniques, nuclear magnetic resonance, vibrational and electronic spectroscopy, microscopy, and thermal and dynamic mechanical methods.

References:

- 1- *Polymer Characterization*: D. Campbell, J. R. White
- 2- *Polymer analysis*: Barbara H. Stuart
- 3- *Analysis of Polymer Systems*: L. S. Bark, N. S. Allen
- 4- *Polymer Characterization*: Nicholas P. Cheremisinoff

❖ Rubber Engineering (Credits: 3, Theoretical)



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Main Topics: Properties of elastomers, relation between structures and mechanical and rheological properties of elastomers, rubber elasticity and its role in properties and process behavior of elastomers, rubber elasticity theories and thermodynamics, rubber compounding and processing (rubber compound formulation, batch and continuous rubber processing and their theories), vulcanization of elastomers (crosslinking, vulcanization methods, role of different additives in vulcanization, vulcanization kinetics and heat transfer), mechanical and rheological behavior of reinforced elastomers, formation of elastomer compounds in batch and continuous processes, injection molding, compression molding, de-vulcanization and recycling of vulcanized elastomers.

References:

1. The Science and Technology of Rubber (James E. Mark)
2. Development in Rubber Technology (Whelan).
3. Science and Technology of Rubber (F.R.EIRICH).
4. Rubber processing (James L.White)
5. Vulcanization of Elastomers (G.ALLIGER).
6. Mixing of Rubbers (R.F Grossman).
7. Basic Rubber Compounding and processing (Harry. Long).

❖ Rubber Engineering Workshop (Credits: 1,Experimental)

This course is in companion with Rubber Engineering.

❖ Plastic Engineering (Credits: 3, Theoretical)

Main Topics: A brief overview and history of plastic materials and discussion about some of the issues surrounding plastic materials in today's society, mechanical behavior and physical properties of plastics in comparison to metals, structure, properties and application of plastics, rheological behavior of polymer melts and its effect on formation of polymers, elastic response of polymer melts and methods to control it, extrusion process and extruders, different sections of screws and their role in processing of polymers, different equations and flow properties in metering section of a single screw extruder, characteristic equations of isothermal conditions, power used and energy conversion equations in extruders, pipe processing and controlling parameters, compression molding (process, different parameters, design of the molds, polymer flow in different parts of a



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mold, molecular structure of a compression molding product, shrinkage, relation between rheological behavior, thermodynamics and structure and properties of the product), methods of processing mono and multilayer films, polymer mixing and compounding.

❖ Plastic Engineering Workshop (Credits: 1, Experimental)

This course is in companion with Plastic Engineering.

❖ Composite Technology (Credits: 3, Theoretical)

Main Topics: Chapter1: importance of composites in material engineering, application of composites, different structures of composites- Chapter2: matrixes (role of matrixes in structure of composites, epoxies, polyesters, vinyl-esters and other matrixes)- Chapter3: fiber reinforced polymers (glass, carbon and aramid fibers)- Chapter4: toughness properties of layers containing continuous fibers- Chapter5: resistance properties of layers containing continuous fibers- Chapter6: Toughness and resistance properties of layers containing unidirectional/accidentally directed batch fibers- Chapter7: toughness and resistance of layers under thermal load in humid condition (penetration in composites, micro-mechanic calculations)- Chapter8: formation processes of composites (composites formation calculations, selecting proper process, bagging processes, resin injection processes)

❖ Composite Technology Workshop (Credits: 1, Experimental)

This course is in companion with Composite Technology.

❖ Fiber Engineering (Credits: 3, Theoretical)

Main Topics: Common fibers, Mechanical properties of fibers, Electrical properties of fibers, Optical properties of fibers, Thermal properties of fibers, Spinning methods (wet spinning, melt spinning and gel spinning).

❖ Polymerization Engineering (Credits: 3, Theoretical)

Main Topics: condensation and addition polymers - molecular weight and molecular weight distribution (methods of determining them, frequency function and moments, skewness and



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flattening, the binomial distribution, the Schultz-Flory most probable distribution, the Schultz distribution, the generalized exponential distribution, the normal distribution, the logarithmic normal distribution, the Poisson distribution and bimodal distribution)- step polymerization (kinetics, polymerization systems, step copolymerization, polymer blends)- radical-chain polymerization (kinetics, cage effect, dead-end polymerization, chain transfer, inhibition and retardation, thermodynamics of polymerization, autoacceleration, living radical polymerization, atom transfer radical polymerization, ligands, initiators)- ionic chain polymerization (cationic polymerization: kinetics and molecular weight distribution, anionic polymerization: kinetics of living polymerization)- chain copolymerization (types of copolymers, copolymer composition, radical copolymerization, cationic copolymerization, anionic copolymerization, application of copolymerization)- ring opening copolymerization.

❖ Rheology of Polymers (Credits: 3, Theoretical)

Main Topics: Introduction to stress, strain, deformation and kinematics of fluids- material characteristics- dynamics of fluids and flow fields- Fluid Classification- Non-Newtonian fluids and fluid models- fluid behavior (stress relaxation, creep, recovery, viscoelasticity phenomena, die swelling- Eisenberg effect), Viscometry and Rheometry (capillary rheometer, coaxial cylinder viscometer, cone and plate viscometer), rheogonimeter, material function and its application, analysis of isothermal flow in different fields (pipes, annulus and slit), analysis of non-isothermal flow in pipes, rheology of suspension (anticipating its viscosity using different models).

References:

- 1-Rheology of polymeric systems: Principles and application
- 2-P. J. Carreau, D. C. De Kee, R. P. Chhabra
- 3- Non-Newtonian fluids, Wilkinson
- 4-Non-Newtonian Flow and Applied Rheology: Engineering Applications
- 5-R. P. Chhabra, J. F. Richardson
- 6- Transport phenomena, L. Byron Bird
- 7- Dynamics of polymeric Liquids L. Byron Bird
- 8- Polymer Rheology, Nielson



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- ❖ **Practical Training** (Credits: 2, Experimental) (This course does not count in GPA & total credits)

Students must reside for 320 hours in some polymer production and/or processing industries sites.

- ❖ **B.Sc. Project** (Credits: 3, Theoretical-Experimental)

Specialized (Elective) Courses:

- ❖ **Technical English** (Credits: 2, Theoretical)

Main Topics: Definition of Modern Science versus traditional Science, Definition of Term and word, Impact of terminology on technology transfer and understanding, Introduction of Polymer glossaries and dictionaries, Understanding of scientific suffixes and prefixes in English and Persian, Defining of term coining methods, Defining different types of papers and its constituents, Introduction to scientific writing style, Introduction to presentation skills.

- ❖ **Industrial Management** (Credits: 2, Theoretical)

Main Topics: Management in history, Management in industries, Strategic management, Production management, Planning, Quality.

- ❖ **Properties and Application of Natural Polymers** (Credits: 2, Theoretical)

Main Topics: Definitions related to natural polymers , their sources and differences to synthesis polymers, proteins (characteristics, structures and etc.)- different types of proteins, their application and sources- protein fibers and their application- polysaccharides, their structure and types and application in different industries- cellulose, its structure and characteristics, sources and application- lignin, graphite and diamond, their structure, sources and application in different industries- poly-silicates, their structure and different types and usage in synthesis polymers.



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❖ Industrial Resins (Credits: 2, Theoretical)

Main Topics:

- 1- How to design, synthesize, formulate and evaluate polymeric coatings.
- 2- Pigments and nano-fillers; extender pigments, pigment volume concentration, metal and corrosion inhibiting pigments.
- 3- Additives in coatings; their functions and uses.
- 4- Chemistry and interactions of coatings components.
- 5- Coating formulations including examples of trade sales, industrial and specialty coatings.
- 6- Polyesters, acrylics, vinyl acrylics, polyurethanes, epoxy resins, phenolic resins, organosilanes and other silicon containing polymers for coating applications.
- 7- Molecular level processes in polymeric coatings; film formation, stratification of individual components.

❖ Measurements Methods (Credits: 2, Theoretical)

Main Topics: important measuring parameters (pressure, temperature, level and flow-rate), measuring instruments, measuring systems (intrusive & nonintrusive), sensing elements, measuring element (range, error, repeatability & time constant), pressure measurement, temperature and heat measurement, flow-rate measuring, fluid density measurement, measurement of liquids level in tanks.

❖ Petrochemical Processes (Credits: 4, Theoretical)

Main Topics: hydrogen, synthesis gases and their derivatives, sources of olefinic and aromatic hydrocarbons, acetylene, ethylene and propylene oxides, acetic derivatives, alcohols, phenol, acetone and methyl ethyl ketone, vinyl monomers.

❖ Physics II Lab. (Credits: 1, Experimental)

This course is in companion with Physics II.

❖ General Chemistry II (Credits: 3, Theoretical)



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Main Topics: Electrolytes, acid-base couples, strong acids & bases, weak acids & bases, color indicators, polyacids & polybases, buffer solutions, complexes.

❖ **Fluid Mechanics II** (Credits: 2, Theoretical)

Main Topics: Non-Newtonian fluids, two-phase flow, fluidization, flow through porous media, compressible flow, oil extraction from reservoirs

❖ **Process Control Lab.** (Credits: 1, Experimental)

This course is in companion with Process Control.

Mohammad Ali Moosavian, PhD

Chair & Professor

School of Chemical Engineering

College of Engineering

University of Tehran

Email: moosavian@ut.ac.ir

Tel: +98 21 61112203

Fax: +98 21 66957784

