NAZARBAYEV UNIVERSITY
SCHOOL OF ENGINEERING AND DIGITAL SCIENCES

Bachelor of Engineering in Chemical Engineering

Nazarbayev University

Degree requirements for the AY 2020-2021 Graduation Cohort

	Abbr/Number	Courses	Credits ECTS
Major requirements (222 credits)	BENG 124	Engineering Mathematics I	6
	BENG 117	Engineering Mechanics	6
	BENG 145	Occupational, Environmental Health and Safety	6
	BENG 221	Engineering Materials	6
	BENG 146	Programming for Engineers	6
	BENG 225	Engineering Mathematics II	6
	BENG 201	Engineering Economy	6
	BENG 147	Introduction to Fluid Mechanics and Thermodynamics	6
	BENG 148	Engineering Practice	6
	BENG 114	Introduction to Electrical Systems	6
	BENG 228	Engineering Mathematics III	6
	EME 254	Mechanics of Materials	6
	ECHE 126	Introduction to Chemical Engineering	6
	ECHE 222	Chemistry I	6
	ECHE 319	Chemical Engineering Thermodynamics	6
	BENG 219	Control Systems	6
	ECHE 270	Transport Phenomena I	6
	ECHE 221	Engineering Fluid Mechanics	6
	ECHE 210	Foundations of Unit Operations	6
	ECHE 483	Chemistry II	6
	BENG 405	Project Management	6
	ECHE 385	Research Practice	6
	ECHE 369	Transport Phenomena II	6
	ECHE 333	Separation Processes I	6
	ECHE 481	Chemical Reaction Engineering	6
	ECHE 386	Chemical Plant Design and Optimization	6
	ECHE 388	Process Dynamics and Control	6
	ECHE 323	Computational Methods in Chemical Engineering I	6
	ECHE 383	Separation Processes II	6
	ECHE 387	Chemical Reaction Engineering 2	6
	BENG 312	Internship	12
	ECHE 418	Capstone Project 1	6
	ECHE 486	Chemical Process Safety	6
	ECHE 479	Capstone Project II	18
General requirements (18 credits)	HST 100	History of Kazakhstan	6
	KAZ XXX	Kazakh Language Course	6
	KAZ XXX	Kazakh Language Course	6
Specific Electives (30 credits)		Discipline Elective 1	6
		Discipline Elective 2	6
		Discipline Elective 3	6
		Discipline Elective 4	6
		Discipline Elective 5	6
Total credits			**270**

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*List of Chemical Engineering Elective courses**

ECHE 419 Advanced Process Simulation
ECHE 420 Polymer Processing and Rheology
ECHE 421 Tissue Engineering
ECHE 463 Introduction to Molecular Modeling Methods
ECHE 478 Electrochemical Engineering and Corrosion Protection
ECHE 484 Multi-Phase Flows
ECHE 484 Multiphase Systems
ECHE 485 Introduction to Biochemical Engineering
ECHE 487 Soft Matter, Foods and Colloids
ECHE 488 Atmospheric Chemistry and Physics
CHME 350 Soft Matter, Foods and Colloids
CHME 351 Environment and Development
CHME 454 Transport Phenomena and Operations
CHME 461 Powder technology

**According to the Program Proposal, courses from other schools may be considered as electives after the approval process in the School. The list of electives may be subject to changes.*

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DETAILED COURSE DESCRIPTIONS

Year 1, Fall Semester

Course Title 6 ECTS	**Engineering Mechanics**
Course Descriptor	This module consists of application of Newton's Laws to equilibrium of particle and rigid body and reactions developed internally and externally due to application of the loads and study of simple mechanical planar motion of a particle through consideration of forces, work, energy and momentum and its conservation using different coordinate systems.
Course LOs	1) Identify equilibrium conditions for a particle and rigid body. 2) Evaluate internal forces and moments developed in the rigid body due to external loading. 3) Apply the fundamentals of kinematics of particle in planar motion in different coordinate systems. 4) Analyze and evaluate motion of particle using work-energy and impulse-momentum concepts.

Course Title 6 ECTS	**Programming for Engineers**
Course Descriptor	This is an introductory course for programming essential for Engineering undergraduate study. The module would focus on the development of programming skills that can be directly applied to solve engineering problems where the computer is part of the system, or is used to model a physical or logical system. This module introduces programming as a tool for solving engineering problems through C and Java programming languages. This is an introductory course providing foundational programming to Chemical, Mechanical, Civil and Electrical Engineers.
Course LOs	1) Develop programming solutions to open ended engineering problems. 2) Infer alternate solutions to programming problems. 3) Develop software specifically using C and Java programming languages. 4) Apply knowledge of programming to solve practically relevant engineering problems. 5) Use the object-oriented concepts to write optimal and efficient codes.

Course Title 6 ECTS	**Occupational, Environmental Health and Safety**
Course Descriptor	The module covers: Introduction to Risk Management: Hazards Identification, Risk Assessment (Hazards Analysis) and Risk Control (including probabilities lectures) Occupational Health and Safety: Occupational Health Hazards, Ergonomics, Human Health Risk Assessment, Health and Safety Practice, Hazardous Chemicals, Personal Protective Equipment Environmental Health and Safety: Environmental Hazards, Indoor and Ambient Air Quality, Soil Pollution, Water Pollution, Solid Waste Management (including Hazardous Waste), Noise Pollution, Environmental Auditing And Impact Assessments, Guidelines, Standards And Regulations.
Course LOs	1) Identify what is Hazard, Risk, Barriers & Mitigation measures and perform hazard identification exercises.

	2) Apply Qualitative, semi-Quantitative and Quantitative/Probabilistic Risk Analysis methods. 3) Identify and analyze the effects of toxic substances on health and the environment and how to implement appropriate environmental control measures. 4) Develop employee health programs that will improve health in the work environment. 5) Describe Occupational Hazards and explain the use of Personal Protective Equipment.

Course Title 6 ECTS	**Engineering Materials**
Course Descriptor	The module covers the fundamentals of materials science and engineering. These include the understanding of the material structure from the atomic to micro to macro levels. The effects of the structure and the processing techniques on the material properties will be discussed. These concepts will be illustrated using metals to allow students to utilize the knowledge for materials selection in common engineering applications.
Course LOs	1) Explain the influences of microscopic structure and defects on material properties, including dislocation and strengthening mechanisms. 2) Design and control heat treatment procedures to achieve a set of desirable mechanical characteristics for common metals. 3) Evaluate the applications and processing of common engineering materials including metals & their alloys. 4) Utilize the knowledge in materials selection processes taking further considerations of the economic, environmental and social issues.

Course Title 6 ECTS	**Engineering Mathematics I**
Course Descriptor	*This module will cover:* Differential and Integral calculus of real valued functions of single variable. Sequences, infinite series and power series. Elements of linear algebra: matrices and eigen functions. Vector algebra and three-dimensional analytic geometry. Polar and Cartesian coordinates.
Course LOs	1) Articulate scientific reasoning utilizing the formalism of differential calculus of single variable functions. 2) Demonstrate advanced skills on integral calculus. 3) Assemble mathematical techniques concerning series and matrices for solving engineering problems. 4) Analyze geometrical problems with vector algebra. 5) Compute analytically mathematical problems with the help of mathematical software. 6) Appraise numerically mathematical tasks using mathematical software.

Year 1, Spring Semester

Course Title 6 ECTS	**Engineering Mathematics II**
Course Descriptor	This module will cover: 1) The calculus of multivariate functions. 2) The calculus of vector-valued functions.

	3) Fourier series. 4) Elementary complex variable theory.
Course LOs	1) Be able to differentiate a large array of multivariate functions using partial differentiation and the various partial derivative chain rules. 2) Use different functions, series and optimization methods. 3) Integrate scalar and vector fields along contours in three-dimensional space. 4) Express a line integral as a double integral, area integral as a triple integral. 5) Use *Mathematica/SAGE* to aid calculations and visualization.

Course Title 6 ECTS	**Engineering Economy**
Course Descriptor	This course gives the student an understanding of how the use of capital is perceived by individual stakeholders in project economic analysis. The course answers the questions, why and how a financial feasibility assessment is performed, who should be involved, where and when it should be performed, what data should be used and how financial assessments should be presented.
Course LOs	Evaluate decision making processes for project feasibility Use economic decision making tools, including present worth, annual worth, benefit cost analysis, capitalized costs, rate of return, payback/breakeven analysis. Apply the principles of Value Engineering through team led Projects. Evaluate basic economic and financial principles and their effects on project economics (supply/demand, inflation, and cost of capital, depreciation and tax considerations).

Course Title 6 ECTS	**Introduction to Fluid Mechanics and Thermodynamics**
Course Descriptor	This course provides to the engineering student an introduction to the basic principles of Fluid Mechanics and Thermodynamics, and how to apply them to analyze an engineering problem. It includes an introduction to Fluid Mechanics (fluid properties, conservation laws applied to fluid flow, Bernoulli equation, dimensional analysis, flow visualization, integral flow analysis and fluid transport through pipes) and Engineering Thermodynamics (first/second laws of thermodynamics and their applications).
Course LOs	1) Identify the properties of a fluid and classify fluids in categories. Calculate stress/strain of a Newtonian fluid and pressure/density/temperature of an ideal gas. 2) Calculate the pressure variation and compute the force on an immersed surface due to the presence of a static fluid. 3) Characterize fluid flow (laminar, turbulent, compressible, etc.) and use dimensional analysis to obtain the dimensionless groups associated with a physical problem and applies similarity to relate the conditions of the prototype with its model. 4) Perform a Control Volume Analysis and apply the Conservation Laws (mass, momentum, energy, Bernoulli equation) to analyze a problem (e.g., losses in pipes). 5) Apply the first law of thermodynamics in closed and open systems.

Course Title 6 ECTS	**Engineering Practice**
Course Descriptor	It is the introductory lecture class for year 1 students. The course focuses on introduction to engineering and engineering disciplines, engineering ethics, communication skills, study skills and problem solving skills, design, computing skills, and fundamentals of engineering science.
Course LOs	1) Identify the various disciplines and the role of engineer in the society. 2) Explain career planning in engineering. 3) Explain engineering ethics. 4) Implement schematic approach for engineering problem solving and engineering design. 5) Illustrate engineering communication skills by writing technical reports and applying computer skills. 6) Search for information via traditional and online sources.

Course Title 6 ECTS	**Introduction to Electrical Systems**
Course Descriptor	The aim of the course is to provide an introduction to the principles of electrical and electronic engineering, to develop problem solving skills and to develop basic body of knowledge to serve as a foundation for more advanced studies in electrical and electronic engineering. Course content: 1) Circuits: Electrical quantities, Kirchhoff's laws, resistive, capacitive and inductive circuits, transients, Thévenin and Norton equivalent circuits, steady state sinusoidal analysis, three phase circuits, frequency response, Bode plots and resonance. 2) Analogue electronics: Operational amplifiers, summers, differentiators, integrators, filters. 3) Digital electronics**:** Boolean algebra, Logic circuits
Course LOs	1) Apply electrical engineering principles and applications. 2) Demonstrate ability to use the circuit theory and analyze analogue and digital electronic systems, magnetic circuit and transformers. 3) Construct and analyze simple R-L-C, operational amplifier, and logic circuits. 4) Use computer aided design tools to design and simulate electrical and electronic circuits.

Year 2, Fall Semester

Course Title 6 ECTS	**Engineering Mathematics III**
Course Descriptor	Differential equations of first- and second-order Series solution of differential equations Laplace transforms and its application to the solution of initial value problems Some of the important special functions used in engineering. Introduction to probability and mathematical statistics
Course LOs	1) Solve a large class of first- and second-order differential equations analytically using standard techniques. 2) Model simple physical situations encountered in engineering using first- and second-order differential equations. 3) Use Laplace transform techniques to solve first- and second-order initial value problems.

	4) Recognize and work with a number of the higher transcendental functions of mathematics. 5) Recognize and apply the fundamental axioms of probability. 6) Recognize and work with a range of discrete and continuous random variable probability distributions functions. 7) Calculate confidence intervals and understand when to use the Student t- and chi-squared distributions. 8) Develop skills in Mathematica.

Course Title 6 ECTS	**Mechanics of Materials**
Course Descriptor	This course introduces students to the basic concepts of stresses based on the principles of mechanics. The course covers different types of stresses (axial, bearing, shear, and bending) as well as the deformation of structures or machine components caused by a typical stress component or combined loading conditions. Students would be able to develop their engineering capabilities through applications of the concepts in the analysis and design of engineering structures and machine components.
Course LOs	1) Relate the basic concepts of geometric compatibility and force-deformation as applied to simple deformable elements of structures and machines. 2) Determine stress, strain and deformation in a non-rigid body subjected to various types of loading including axial, torsion and bending. 3) Apply equations of static equilibrium, geometric compatibility and force-deformation to design simple machine or structural elements.

Course Title 6 ECTS	**Introduction to Chemical Engineering**
Course Descriptor	Introduction to engineering calculations: processes and process variables, units and dimensions, fundamentals of material and energy balances, process classification (batch, continuous, semi-batch, steady state, unsteady state, closed and open systems), degrees-of freedom analysis, phase equilibrium and phase diagrams and introduction to chemical reaction kinetics.
Course LOs	1) Apply all basic engineering calculations. 2) Formulate and solve material and energy balance problems. 3) Describe the properties of gases, liquids, and vapors. 4) Articulate the core principles of thermodynamics and kinetics.

Course Title 6 ECTS	**Chemistry I**
Course Descriptor	Introduction to the fundamental concepts of physical and inorganic chemistry such as atomic structure, classification of compounds and chemical bonding to be followed by a rigorous approach to chemical thermodynamics and kinetics. It is expected that students have a working knowledge of differential and integral calculus or equivalent.
Course LOs	1) Define the electronic structure of atoms. 2) Associate predictive theories with molecular geometry. 3) Describe the gas laws (ideal and van der Waals) and the behavior of gaseous systems. 4) Explain aspects of thermodynamics such as internal energy, enthalpy, entropy, free energy, calorimetry. 5) Apply differential and integrated laws to chemical kinetics and chemical equilibria.

	6) Operate equipment, tools or processes and handles relevant materials as applied to chemistry in a laboratory setting.

Course Title 6 ECTS	**Chemical Engineering Thermodynamics**
Course Descriptor	The course covers phase equilibrium problems and modeling, the concepts of chemical potential and fugacity, flash calculations, interpretation of experimental data and selection of appropriate models to describe thermodynamics of mixtures with multiple phases and chemical reaction equilibrium
Course LOs	1) Apply fundamental thermodynamic equations, and estimate physical and thermodynamic properties of pure substances and mixtures. 2) Describe the concepts of chemical potential, fugacity, and activity coefficients. 3) Utilize phase equilibrium diagrams.

Year 2, Spring Semester

Course Title 6 ECTS	**Control Systems**
Course Descriptor	This is a core module. It covers the use of mathematical modeling for the analysis of system dynamics. The students' ability and creativity in the subject will be developed through lectures, HW assignments, and computer laboratory exercises
Course LOs	1) Explain the concept of modeling dynamic systems and the use of different representations. 2) Derive mathematical models of various dynamic systems. 3) Represent the system in various forms such as block diagrams, transfer functions and state space descriptions. 4) Use the system models to study the behavior in the time and frequency domains. 5) Use modern computer tools to simulate and analyze dynamic system behaviors.

Course Title 6 ECTS	**Transport Phenomena I**
Course Descriptor	The module will cover: 1) Momentum, Energy and Mass Transport Interpretation as Transport Phenomena 2) Heat Transfer: Conduction, Convection, Radiation 3) Heat Exchangers 4) Mass Transfer: Diffusion and Convection 5) Transport Processes and Unit Operations 6) Laboratory supplement
Course LOs	1) Analyze the transport problems involving mass and/or heat transfer and determine the key factors that control the rate of the process. 2) Derive equations that lead to the solution of steady- and unsteady-state mass and heat transfer problems 3) Apply heat and mass transfer theory and methods to solve engineering problems. 4) Design a heat exchanger for a specific transport phenomena process.

Course Title 6 ECTS	**Engineering Fluid Mechanics**
Course Descriptor	The course focuses on the chapters of the fluid mechanics which are widely used in chemical engineering processes and applications, namely: details and interpretation of Navier-Stokes equation, the boundary layer concept, characteristics of turbulent flow, flow specifics in chemical engineering equipment, pumps & compressors, flow in porous media, flow through packed beds, fluidization, Non-Newtonian fluids, and flow in presence of chemical reactions, are expected to be covered in the course Fluid Mechanics for Chemical Engineers.
Course LOs	1) To employ the basic principles, engineering models and equations of engineering fluid mechanics. 2) To apply dimensional analysis and similarity solutions under problems of scaling and selection of equipment. 3) To predict flow pattern and hydraulic resistance for typical components in chemical engineering equipment. 4) Determine flow rate, pressure drops and required pump characteristics for the typical system consisting of tanks, vessels, pipes, pumps and fitting elements. 5) To predict the impact of the fluid flow characteristics on the rate of mixing processes and chemical reactions.

Course Title 6 ECTS	**Foundations of Unit Operations**
Course Descriptor	The course covers the common unit operations which deal with the transfer and change of energy and the transfer and change of materials, primarily by physical means but also by physical-chemical means, namely: 1) transportation and metering of fluids; 2) agitation and mixing of liquids; particularly, in application with chemical reactors; 3) heat transfer operations, including freezing, boiling, condensation; 4) evaporation, drying, and humidification; 5) flash, batch and steam distillation; 6) batch adsorption; 7) handling of particulate solids, including fluidization, alongside with description and specification of the equipment, instruments and technique required for deployment of the above mentioned unit operations, namely: pumps & compressors, flowmeters, control valves, agitators, heat exchangers, dryers, reboilers, condensers, absorption and distillation columns, catalytic beds, particulate feeders etc.
Course LOs	1) Analyze the functioning of the processing plant as a set of unit operations. 2) Perform the energy and mass balance over a specify unit operation. 3) Specify equipment and control means for the typical unit operations. 4) Assess applicability of the specified unit operation to comply with a given technological process, including clarification of advantages, restrictions, and safety issues.

Course Title 6 ECTS	**Chemistry II**
Course Descriptor	This module deals primarily with the basic principles to understand the structure and reactivity of organic molecules, including physical shape, stereochemistry and reactivity of common organic molecules.

Course LOs	1) Enumerate atomic structure, orbitals, nomenclature conventions. 2) Classify structure, nomenclature and review physicochemical properties of hydrocarbons. 3) Describe chemical reactivity of bonds and organic chemicals: alkenes, alkynes, aromatics, amines, carboxyl, alcohol, thiol, cyanohydrin, hydrogenation. 4) Classify all basic organic chemistry reactions: addition, SN1, SN2, E1, E2, polymerization, halogenation, reduction, basic organometallic. 5) Label spectra of hydrocarbons.

Year 3, Fall Semester

Course Title 6 ECTS	**Project Management**
Course Descriptor	The purpose of this module is to introduce theoretical and practical perspectives to project management and understanding of project management principles. The module introduces students to five basic process groups of the Project Management Body of Knowledge (PMBOK) guide and ISO 21500, namely, the Initiation, Planning, Execution, Monitoring and Control and Closing of projects. Students will learn people skills; practices and processes for more effective project management and how to apply project management tools to ensure planned time, budget, and performance are achieved per project owner requirement.
Course LOs	1) Explain the process of project management and its application in delivering various successful projects. 2) Develop the scope of work, cost estimate, and baseline plan for project evaluation. 3) Identify the resources required for a project to produce a work plan and resource schedule. 4) Analyze project risk factors and develop risk management plans.

Course Title 6 ECTS	**Research Practice**
Course Descriptor	The course is a student centered research project and is structured to establish a project team, assignment of tasks to individual members, coordinated contribution to research and dissemination, identification of specific problems or design issues, structured analysis of the problems, investigation of solutions, communication of ideas and outcomes, conceptual design, design planning & development. The research topics cross the boundaries of the chemical engineering discipline and will range from experimental to computer laboratories.
Course LOs	1) Discuss the core ideas and key findings gained from a literature review on a specified topic (Background/Introduction). 2) Utilize and operate specific experimental tools or software related to the performed research (Materials and Methods). 3) Clearly present and discuss his/her research findings or proposed research within the context of other research studies in the field (Results and Discussion+ Oral Presentation). 4) Formulate and propose an idea for a future research study related to the performed research (Conclusion). 5) Recognize and state the underpinning science and mathematics, and associated engineering disciplines (Q&A after Oral Presentation).

Course Title 6 ECTS	**Transport Phenomena II**
Course Descriptor	The course aims to provide an in depth knowledge of heat, mass and momentum transport that is necessary in assessing, analyzing and developing typical chemical engineering and environmental technologies. The course focuses on modeling momentum, heat & mass transfer processes using analytical and numerical solutions of the partial differential equations of transport phenomena.
Course LOs	1) Assess the similarities between the transport processes and the effect of properties of the media on the overall process. 2) Apply the techniques for non-dimensionalized problems and construct the parameters that govern the evolution of transport phenomena. 3) Develop the model of transport phenomena and obtain analytical or numerical solutions of the appropriate partial differential equations resulted in profiles of velocity, temperature, and concentration. 4) Develop and solve the model describing the combined effect of heat, mass and momentum transport in a typical chemical engineering equipment (heat exchanger, catalyst bed, chemical reactor, etc.).

Course Title 6 ECTS	**Separation Processes I**
Course Descriptor	This course covers the fundamentals of mass transfer operations, i.e. equilibrium-stage and rate (diffusional) processes that involve liquid and gaseous phases (or inert solid as packing material).
Course LOs	1) Identify, analyze and calculate appropriate mass transfer separation processes involving fluid phases using experimental, tabulated, literature and other numerical data. 2) Justify the selection of appropriate equipment for mass transfer separation processes involving fluid phases in process plants. 3) Identify the limitations of approximate design methods and demonstrate how these can be improved/extended by use of computer software packages. 4) Design and evaluate separation systems using computer modelling or specialized software

Course Title 6 ECTS	**Chemical Reaction Engineering I**
Course Descriptor	This course covers the fundamentals of chemical reaction engineering and covers the main concepts and principles regarding the design of homogeneous reactors.
Course LOs	1) Analyze and interpret kinetic data; 2) Select and size the most appropriate reactor type for a specific task. 3) Define the most effective reactor sequence. 4) Relate the flow regime with the efficiency of a reactor for multiple reactions. 5) Apply numerical techniques in chemical reaction engineering problems. 6) Articulate a chemical reaction engineering project in front of an audience.

Year 3, Spring Semester

Course Title 6 ECTS	**Chemical Plant Design and Optimization**
Course Descriptor	In a typical plant design project, the conceptual design contributes with less than 5% to the total project cost, but offer opportunities for saving more than 30% of the life-cycle costs. This course addresses the use of systemic and systematic techniques for conceptual and detailed design of chemical processes. Analytical solutions and short-cut methods are used for getting physical insight and finding feasible alternatives. Thus, the course presents the hierarchical methodology to conceptual process design and optimization, with emphasis on: understanding the behavior of reaction – separation – recycle systems; chemical reactor selection; synthesis of the separation section; process intensification and integration. This course also involves the concepts presented in other chemical engineering courses such as mass and energy balance, transport phenomena, fluid mechanicns and reaction engineering to select and size necessary equipment to design a chemical plant. These equipment includes but are not limited to reactors, separation columns, heat exchangers, pumps, compressors, piping, valves, etc.The course aims to discuss economic principles as applied in chemical engineering processes and operations. It includes analysis of cost estimation of chemical process equipment; calculations of interest rates, taxes, and depreciation for a process plant; decision making based on financial considerations. Finally, this course presents different aspencts of plant optimization including principles of energy integration and optimization (pinch technology).
Course LOs	1) Applies the systemic approach for solving the design problems. 2) Develops PFD of a process with demosntrated mass and energy balances. 3) Implements optimization methods to reduce energy consumption and environmental impact of the plant. 4) Sizes the plant equipment including heat exchangers, packed and tray columns, reactors, pumps, compressors, turbines, valve, pipes, etc. 5) Identifies the various costs involved in chemical processes including capital and operating cost, investment returns relevant to a chemical plant, etc. 6) Designs a given case study by using a commercial process simulator.

Course Title 6 ECTS	**Process Dynamics and Control**
Course Descriptor	This course introduces the principles of chemical process dynamics and modelling. Methods and techniques are developed for the analysis, design and simulation of automatic control systems for chemical process plants. Subject covers modelling of static and dynamic behaviour and stability of processes; principles of process instrumentation, control strategies; design of feedback, feedforward, and other control structures; stability analysis, multivariable interaction analysis, control loop pairings, and process control and dynamics simulations.
Course LOs	1) Formulation of dynamic models for chemical processes. 2) Control system instrumentation and feedback control. 3) Design and tune a PID controller. 4) Perform frequency response analysis and design control systems. 5) Use control software simulation. 6) Perform conceptual design of plant-wide process control.

Course Title 6 ECTS	**Computational Methods in Chemical Engineering**
Course Descriptor	This course focuses on the development of process flowsheet, their implementation into commercial software and their use for process evaluation. The course starts with a brief review of applied chemical engineering thermodynamics focusing on process simulation thermodynamics. Then, several unit operation models (mixers and splitters, pressure change units, heat exchangers, phase separation, distillation columns, chemical reactors) are presented, with focus on their use for solving rating and design problems. The sequential-modular approaches to simulation of the entire flowsheet are discussed, including specific numerical solution algorithms. The course also covers more specific cases in chemical engineering including electrolyte systems and solids. Advanced flowsheeting including estimating missing components in the flowsheets, data regression, ssensitivity analysis, optimization and user-defined models are also introduced.
Course LOs	1) Transfer available components in the flowsheet to the process simulator 2) Select the most suitable thermodynamic models for predicting mixture phase equilibrium 3) Evaluate rating and design studies of unit operations, with the help of commercial flowsheeting tools. 4) Build the simulation model of an entire chemical process including material recycle 5) Critique the key design variables and suggest design changes, with the aim of process optimisation. 6) Plan a flowsheeting problem through team work, report the results in writing, and defend the project work by oral presentation.

Course Title 6 ECTS	**Separation Processes II**
Course Descriptor	This course covers the fundamentals of mass transfer operations, i.e. equilibrium-stage and rate (diffusional) processes that involve liquid and gaseous phases (or inert solid as packing material).
Course LOs	1) Identify, analyze and calculate appropriate mass transfer separation processes involving fluid phases using experimental, tabulated, literature and other numerical data. 2) Justify the selection of appropriate equipment for mass transfer separation processes involving fluid phases in process plants. 3) Identify the limitations of approximate design methods and demonstrate how these can be improved/extended by use of computer software packages. 4) Design and evaluate separation systems using computer modelling or specialized software.

Course Title 6 ECTS	**Chemical Reaction Engineering II**
Course Descriptor	This course covers the fundamentals of heterogeneous reacting system and covers the main concepts and principles regarding the design of non-ideal reactors.
Course LOs	1) Find and use the residence time distribution in non-ideal reactors. 2) Estimate the conversion and size in the case of non-ideal reactors. 3) Formulate rate equations for surface kinetics. 4) Estimate Thiele modulus for various shapes of catalyst particles. 5) Design heterogeneous reactors.

	6) Articulate a chemical reaction engineering project in front of an audience.

Course Title 12 ECTS	**Summer Internship**
Course Descriptor	This module will provide an opportunity for students to develop the professional skills and gain initial experience of application of theoretical knowledge in real engineering work.
Course LOs	1) Relate engineering principles and/or experiments to industry practices as well as solutions of practical problems in professional settings. 2) Communicate and function effectively within industry systems and practices. 3) Assume the professional, ethical and social responsibilities in industrial settings. 4) Evaluate the appropriateness of acquired techniques, skills, and modern engineering tools, as well as reflect on the work experience and its implications for continuous improvement. 5) Demonstrate the ability to work with technical uncertainties in engineering environments.

Year 4, Fall Semester

Course Title 6 ECTS	**Chemical Process Safety**
Course Descriptor	The course covers the major process safety and loss prevention issues that affect process industries.
Course LOs	1) Apply risk management concepts and techniques. 2) Identify and analyze toxicity and apply basic industrial hygiene practices. 3) Classify and describe major hazards like fires & explosions and toxic releases. 4) Apply relief methodologies and be able to perform conceptual design of relief devices. 5) Analyze industrial accidents and identify the causes, and propose safety measures (case study analysis).

Course Title 6 ECTS	**Capstone Project I**
Course Descriptor	This course covers all the steps required to design a fully operational process plant. Students will work on the design of an assigned project selected from a diverse range of process industries or final products. The successful completion of the Capstone course involves the application of a wide range of skills taught throughout the program such as chemical engineering fundamentals, data gathering, project management, safety considerations, environmental considerations, economic evaluation, leadership and membership of teams, report writing and project presentation. Students work in teams to apply their knowledge and skills acquired during the program of their undergraduate education and will conduct both team and individual assignments.
Course LOs	1) Identify the objectives and context of the design within a structured approach to safety, health and sustainability. 2) Understand that design is an open-ended process, lacking a predetermined solution, in many cases based on incomplete and contradictory information, with variable constraints and multiple objectives. 3) Apply a systems approach to design appreciating complexity, interaction,

	integration. 4) Work in a team and understand and manage the processes of: peer challenge; planning, prioritizing and organizing team activity; the discipline of mutual dependency. 5) Apply design processes and methodologies and adapt them in unfamiliar situations. 6) Work with information that may be incomplete or uncertain, quantify the effect of this on the design. These Learning Outcomes are combined with those of Capstone II.

Year 4, Spring Semester

Course Title 18 ECTS	**Capstone Project II**
Course Descriptor	This course covers all the steps required to design a fully operational process plant. Students will work on the design of an assigned project selected from a diverse range of process industries or final products. The successful completion of the Capstone course involves the application of a wide range of skills taught throughout the program such as chemical engineering fundamentals, data gathering, project management, safety considerations, environmental considerations, economic evaluation, leadership and membership of teams, report writing and project presentation. Students work in teams to apply their knowledge and skills acquired during the program of their undergraduate education and will conduct both team and individual assignments.
Course LOs	1) Apply a systems approach to design appreciating complexity, interaction, integration. 2) Work in a team and in an individual capacity and understand and manage the processes of: peer challenge; planning, prioritizing and organizing team activity; the discipline of mutual dependency and integration of individual parts into an overarching plan. 3) Articulate the outcomes of the design with the appropriate amount of detail, including flowsheet structure, equipment sizing and stream data; explain and defend chosen design options and decisions taken 4) Apply and adapt design processes and methodologies in unfamiliar situations, even when the available information is incomplete or uncertain. 5) Perform Environmental Impact and Life Cycle Analysis. 6) Evaluate financial and other risks. These Learning Outcomes are combined with those of Capstone I.

Course Title 6 ECTS	**Elective – Advanced Process Simulation**
Course Descriptor	The first objective of this course is to introduce advanced tools and skills to chemical engineering students to perform the simulation of complex chemical plants including several recycle streams, design specifications and optimization cases. The second objective of this course is to perform optimization for individual unit operations such as designing cost optimized heat exchangers and feed tray optimization of distillation columns, using commercial simulation softwares. The final objective of this course is to perform plantwide optimization including minimization of hazardous chemical emissions, greenhouse gas emission reduction, energy optimization using pinch technology and total cost minimization by integrating several commercial

	softwares. The content of this course would be applicable to different chemical industries such as petrochemical, oil and gas. The course strts with a review of applied thermodynamics engaged with process simulation at advanced level, and presents how to tune the parameters associted with these models for specfic applications. The course then introduces a novel and accurate modeling concept named as rate-base (nonequilibrium) model and demonstrates its key application in simulation and design of industrial separation processes such as distillation and absorption. Flowsheet convergence using Equation Oriented (EO) approach is presented and sensitivity analysis and optimization in this mode are dicussed. Skills for flowsheet convergence troubleshooting is presented in order for the students to be able to overcome convergence issues in large and complex flowsheets. Cost optimized individual heat exchanger and heatexchanger network desings using advanced commercial softwares are presented in this course. Finally, the sutdents are trained to select final optimal design among various desing options, based on cost considerations using advanced cost estimating commercial softwares. The course utilizes state of the art commercial softwares that are implemented in chemical industries like Aspen Tech. products including Aspen Plus, Aspen Exchanger Design and Rating, Aspen Energy Analyzer and Aspen Process Economic Analyzer and Aspen Capital Cost Estimator to prepare the students to be involved in real insudtrial desing projects.
Course LOs	1) Set up a simulation case for reactive and non-reactive absorption/disitillation columns using the rate-based model. 2) Perform flowsheet optimization and parameter estimation by both E.O. and S.M. approaches using a commercial software. 3) Evaluate flowsheet convergence issues correctly, and implement appropriate methods to troublshoot the problems. 4) Modify the existing flowsheet heat exchanger network to minimize energy consumption using energy analyzing softwares. 5) Select final plant design by performing total plant cost estimation for various design options. 6) Plan a flowsheeting problem through team work, report the results in writing, and defend the project work by oral presentation.

Course Title 6 ECTS	**Elective – Computational Fluid Dynamics**
Course Descriptor	This course gives the student the chance to review and further deepen her/his knowledge in fluid mechanics, heat transfer and numerical methods skills to a level that is fundamental in engineering applications. From the very beginning of the course, the student will be required to program common algorithms related to the solution of differential equations commonly found in fluid mechanics and heat transfer problems, using tools like C++, Matlab of MSExcel for programming. Afterwards, the students will interact with CFD software such as ANSYS-CFX, ANSYS-Fluent, and Open FOAM or similar, during laboratory sessions starting at the first quarter of the semester of the course, to enhance her/his capabilities in solving engineering problems in fluid mechanics and heat transfer.
Course LOs	1) Discriminate between fluid dynamics equations in both vector and Cartesian-tensor notation and with common algorithms and methods. 2) Justify the use of numerical solutions and in understanding their limitations as compared to analytical solutions.

	3) Develop properly interpreted results out of commercial CFD software, with emphasis on the use of commercial software (e.g. ANSYS-CFX/Fluent, Open FOAM or similar) to solve engineering problems. 4) Elaborate in written and verbal manner the engineering results obtained via CFD.

Course Title 6 ECTS	**Elective – Electrochemical Engineering and Corrosion Protection**
Course Descriptor	This course is designed for both undergraduate and graduate engineering students, engineers and will cover aspects of the electrochemical cell (EC), its theory and applications; major industrial electrochemical processes (electrolytic production of metals, corrosion protection and batteries). This course will also enable students to gain hands on experience in experiments in corrosion protection, batteries, fuel dells and electrolysis.
Course LOs	1) Describe the concepts and theory of electrochemistry, galvanic cell (GC) and discriminate between its applications (battery, electrolysis, electroplating). 2) Employ calculations of electrode and cell potentials, electrochemical thermodynamics and kinetics. 3) Explain the mechanisms of and relationships for mass transfer in GC. 4) Justify the use of advanced energy storage and conversion systems with focus on advanced batteries for grid connection of renewable sources; Fuel cells, supercapacitors. 5) Critique the differences between electro synthesis and electro refining. 6) Design industrial electrochemical processes and large scale batteries.

Course Title 6 ECTS	**Elective – Micro and Nano Technology**
Course Descriptor	This is a course in micro and nanotechnology that is designed for chemical engineers. This course provides an overview and examples of the different aspects involved in micro and nanoscale fabrication and it covers characterization of materials on the micro and nanoscale. Moreover, this course examines scientific principles that occur in these technologies and materials. This course explores current and future applications of micro and nanotechnology in chemical engineering applications including the oil and gas industry, food technology, water-treatment technology, and biotechnology.
Course LOs	1) Describe the underlying scientific principles of micro and nanotechnology. 2) Discriminate between diverse micro and nanostructures. 3) Justify the use of characterization tools of micro and nanotechnology. 4) Appraise current and new innovations in micro and nanotechnology. 5) Operate equipment, tools or processes and handle relevant materials as applied to micro and nanotechnology in a laboratory setting.

Course Title 6 ECTS	**Elective – Multi-phase Flows**
Course Descriptor	This module will identify the industrial occurrence of the simultaneous flow of more than one phase and highlight the implications for design. The course will cover the basic principles, engineering models and equations of multi-phase flows and selected multi-phase systems.
Course LOs	1) Discriminate flow pattern and hydraulic resistance for typical gas-liquid flows.

	2) Compare the basic principles, engineering models and equations of gas-liquid flows to apply the most relevant for a given situation. 3) Evaluate conditions for critical flux and other effects associated with boiling and condensations. 4) Design two-phase venting (runaway reaction case). 5) Perform basic calculation on phase separators.

Course Title 6 ECTS	**Elective – Oil and Gas Engineering**
Course Descriptor	The technical knowledge and hands-on experience students gained in this course is specific to industry requirements. During the course of studies, much of the learning will occur in class, during tutorials, labs and through completing a team-based research project.
Course LOs	1) Describe the properties of reservoir rocks and the flow of contained oil and gas. 2) Explain the processes and equipment involved in petroleum production. 3) Describe the economics associated with the recovery and production of hydrocarbons. 4) Classify petroleum products and demonstrate how petrochemicals are manufactured.

Course Title 6 ECTS	**Elective – Mineral Process Engineering**
Course Descriptor	The course covers: 1) Introduction and Overview 2) Ore handling and sampling 3) Material Balances 4) Particle size measurements 5) Mineral Liberation, communition, crushing, grinding, screening, and classification 6) Mineral concentration using gravity, dense medium, magnetic and high tension separators 7) Froth flotation and flotation circuits. Surface tension, Use of reagents: collectors, Frothers, depressants, and activators. 8) Heap leaching, Hydrometallurgy and hydrofracking 9) Dewatering techniques: thickening, filtering, drying, flocculants, and filter aids. 10) Environmental impacts from mining: Acid Drainage, Metals contamination of ground/surface water and sediments, cyanide destruction, waste material and their disposal.
Course LOs	1) Classify commonly occurring processes for mineral beneficiation. 2) Assess the importance of mineral liberation, and principles and processes of crushing, grinding, and size classification. 3) Discriminate between the fundamentals of sampling, gravity, magnetic, electrostatic and forth flotation separation. 4) Distinguish between the environmental issues related to mining industries and the recent strategies and methods for pollution prevention and remediation. 5) Calculate plant stream flows using the mass balance principle. 6) Analyze process data by calculating product yield, recovery, rejection, concentration ratio and efficiency.