ULT Chemical Engineering

Subjects Modules for S5

Semester 1 Year 3

U.5.1Process & Treatments

Water Treatment Process

Module designation	**Process & Treatments**
Module level, if applicable	3rdyear of chemical engineering degree
Code, if applicable	U. 5.1
Subtitle, if applicable	-
Courses, if applicable	- **Water Treatment Process**
Semester (s) in which the module is taught	-Semester 1 (S1)
Person responsible for the module	Dr Khalil ZAGHDOUDI
Lecturer	Phd. Dorra JALLOULI
Language	French
Relation to curriculum	Professional module (compulsory), (S1)
Type of teaching, contact hours	Lecture, 30 hours of classroom course/semester 9 hours of practical workshop in Lab/semester 12 hours of Project classroom course/semester
Workload	Total 72 hours/semester (21 hours of Self-Study/semester)
Credit points	2.5 credits
Requirements according to the examination regulations	- Minimum attendance rate: 80% of the total contact hours >20 % of nonattendance = elimination for exams
Recommended prerequisites	Thermodynamics, Fluid mechanics, Unit Operation, Membrane technology, advanced separation processes, Transfer & transport phenomena.

Module objectives/intended learning outcomes	**Objectives :** 1. Study the principles and design of water treatment processes 2. Know the processes for purifying an effluent before it is discharged (urban or industrial discharge). 3. Study different phases of water treatment design 4. Effectively use and optimize an existing installation; in particular, to optimize the water quality obtained and minimize operating costs **Learning Outcomes:** Students will be able to : 1. Conduct wastewater treatment methods, 2. Characterize water from a chemical and physical point of view. 3. Describe different methods for wastewater treatment and environmental effects of wastewater 4. select technologies that achieve quality objectives at the lowest cost

Content	**Part A: Water chemistry** 1. Classification of water 2. Mineral composition of the water 3. Units used in the analysis of the constituents of water 4.water structure 5. states of water 6. Physical properties of water 7. Chemical properties of water 8. Parameters specific to water chemistry 9. Water behavior 10. Water analysis **Part B: Water treatment techniques** I- The different types of pollution II- General diagram of a wastewater treatment plant 1- Pretreatment 2- Primary treatment (physico-chemical) 3- Secondary (biological) treatment 4- Tertiary treatment 5- Reduction of the population of microorganisms 6- The fate of sludge, recovery, disposal **Part C : MECHANICAL WATER TREATMENT** **Part D : BIOLOGICAL CLEANING** **Part E : CHEMICAL WASTEWATER TREATMENT** 1. Neutralization, 2. Disinfection, 3. Phosphate precipitation, 4. Nitrogen removal, 5. Deicing & manganese removal. **Part F : WATER TREATMENT PROCESSES** 1. Nanofiltration 2. Reverse osmosis 3. Coagulation and flocculation 4. Bioreactors

	Practical workshop in Laboratory- Water treatment (9 hours/ Semester) 1. Determination of osmotic pressure, water permeability and Verification of Van't Hoff law *Objectives :* - Determination of osmotic pressure - Determination of the water permeability of the reverse osmosis membrane - Verification of Van't Hoff law 2. Water treatment by coagulation-flocculation *Objectives :* The aim of this manipulation is to study the influence of the pH and the dose of the coagulant on the efficiency of coagulation-flocculation in water treatment. 3. Study of the softening, decarbonation and demineralization of water by ion exchange resins. *Objectives :* The objective of this manipulation is to demineralize water by ion exchange resin. **12 hours of Project workshop/ Semester** Students are divided into groups of 4 students. A project will be assigned to students group early in the semester. The students will be asked to develop a project plan and will work on project throughout the course. Students groups will work on a given project from the list below **Projet topic :** **Proposal 1**: Treatment of industrial water loaded with resin residue & emulsions. Identification of pollutants. Identification of a treatment pathway.(PROKIM INDUSTRY). **Proposal 2**: Improving the performance of the Bonna wastewater treatment plant. (BOONA INDUSTRY). **Proposal 3:** Improuvming of water station treatment: define water quality, determine the necessary equipment, and choose the suitable process. (SITEP company). **Proposal 4**: study of a hybrid process for the treatment of industrial water. (PROKIM INDUSTRY).
Study and examination requirements and forms of examination	Written Mid-term Exam (20%) + Practical Exam (20%)+Oral Presentation Project (10%)+ Written Final Exam (50%)
Media employed	Course Material (Hard/ Soft copy) for classroom & Online (Moodle ULT) Workshop in Laboratory Video projection Visit to a municipal wastewater treatment plant (ONAS CHOTRANA, Tunis)

Reading list	Advanced BioTech. Wastewater collection and treatment. www.adbio.com. -Agence de l'eau Rhin-Meuse. Les procédés d'épuration des petites collectivités. www.eau-rhin-meuse.fr -EU. 5th Commission Summary on the Implementation of the Urban Waste Water Treatment Directive, 2009. -André PAULUS. Le filtre planté de roseaux, Editions du Rouergue, 2011. - René MOLETTA, La méthanisation. Lavoisier Tec & Doc, 2011 (2ème édition).

U.5.1Process & Treatments

Treatment of Gaseous effluents & Solid Waste

Module designation	**Process & Treatments**
Module level, if applicable	3rd year of chemical engineering
Code, if applicable	U. 5.2
Subtitle, if applicable	-
Courses, if applicable	- **Treatment of Gaseous effluents & Solid Waste**
Semester (s) in which the module is taught	-Semester 1 (S1)
Person responsible for the module	Dr Khalil ZAGHDOUDI
Lecturer	Phd. Khalil ZAGHDOUDI
Language	French
Relation to curriculum	Professional module (compulsory), (S1)
Type of teaching, contact hours	Lecture, 21 hours of classroom course
Workload	Total 42 hours/semester (21 hours of Self-Study/semester)
Credit points	1.5 credits
Requirements according to the examination regulations	- Minimum attendance rate: 80% of the total contact hours >20 % of nonattendance = elimination for exams
Recommended prerequisites	Thermodynamics, Mass& Energy Balance, units operations, fluid mechanics, Advanced separation processes

Module objectives/intended learning outcomes	**Objectives :** 1. Acquire basic knowledge of the treatment processes for aqueous, gaseous and solid industrial effluents 2. Acquire knowledge enabling the design of intrinsically cleaner, more sober and safer processes. 3. Know the different gas treatment processes 4. Choose the most suitable process for the effluent to be treated **Learning Outcomes:** Students will be able to : 1. choose the treatment process best suited to the nature of the effluent, taking into account the possibilities of discharge or recovery 2. know the measures to be taken at the different stages of the design and during the operation of a process in order to make it cleaner, more sober and safer 3. Explain and propose transformation modes of waste into products, by-products and have the knowledge of treatments techniques, 4. Characterize the operation of processing units: mass and energy balances

Content	**Chapter I- Gas effluent treatment** 1. Sustainable development 2. Integrated Production-Clean and Safe Processes 3. Regulations and Standards 4. Upstream processing 5. Air treatment processes 6. Characterization of gaseous effluents 7. Selection criteria 8. Treatment processes: by incineration, catalytic, biological treatment, by adsorption, by absorption, condensation. 9. Treatment of Volatile Organic Compounds (VOCs) 10. Acid Gas Treatment 11. CO_2 treatment **Chapter II- ADSORPTION GAZ/SOLIDE** 1. Processes for the treatment of gaseous effluents by gas/liquid absorption with and without reaction, by dust removal and by adsorption 2. Overview of adsorption 3. Adsorption kinetics 4. Adsorption equilibrium 5. Multicomponent Adsorption 6. Implementation **Chapter III- DUSTING** 1. Introduction 2. Particulate Reminders 3. Mechanical separators 4. Hydraulic separators 5. Filter media separators **6.** Electric separators **Chapter III : GAS/LIQUID ABSORPTION** 1. Introduction 2. physical absorption 3. Absorption with chemical reactions: irreversible reaction order 1.1 then order m,n 4. Transfer in the presence of gas phase resistance **Transfer in the presence of a complex reaction system**

Study and examination requirements and forms of examination	Format: Written Mid-term Exam (40%) + Final Exam (60%)
Media employed	Course Material (Hard/ Soft copy) for classroom & Online (Moodle ULT) Video projection
Reading list	Waste Gas Treatment for Resource Recovery.P Lens, C Kennes, P Le Cloirec, M Deshusses.ISBN13:9781843391272.(2014). E. Guyon, J. P. Hulin, and L. Petit. Hydrodynamique physique. EDP Sciences/CNRS Editions, 2001

U.5.2Environment & Plant Engineering

Environment & Renewable Energy

Module designation	**Environment & Plant Engineering**
Module level, if applicable	3rdyear of chemical engineering
Code, if applicable	U. 5.1
Subtitle, if applicable	-
Courses, if applicable	- **Environment & Renewable Energy**
Semester (s) in which the module is taught	-Semester 1 (S1)
Person responsible for the module	Dr Khalil ZAGHDOUDI
Lecturer	Phd. Nizar SOMRANI
Language	French
Relation to curriculum	Professional module (compulsory), (S1)
Type of teaching, contact hours	Lecture, 21 hours of classroom course
Workload	Total 42 hours/semester (21 hours of Self-Study/semester)
Credit points	1.5 credits
Requirements according to the examination regulations	- Minimum attendance rate: 80% of the total contact hours >20 % of nonattendance = elimination for exams
Recommended prerequisites	Thermodynamics, Mass & Energy Balance, Applied thermodynamic, Fluid mechanic, heat transfer, mass transfer

Module objectives/intended learning outcomes	**Objectives :** 1. Describe basic energy concepts 2. Understand the different processes for transforming primary renewable energy (solar, wind, hydro, geothermal, and biomass) into other secondary forms such electricity 3. Understand the different types of storage and their roles with renewable energies **Learning Outcomes:** Students will be able to : 1. Reflect and evaluate the environmental impact of energy production and the relationship between energy production, consumption and climate change 2. Design the parameters of a consumer scale stand alone and grid connected photovoltaic system for a given site location and performance specification. 3. Optimize the means of electricity production according to the climatic conditions of the site 4. Calculate the major parameters of sun movement, solar radiation, and tracking systems. 5. Calculate wind turbine performance parameters (efficiency, energy produced, capacity factor) for a turbine with given power curve and for a given location with given wind speed distribution function. 6. Recover organic waste

Content	**Classroom Lecture and Guide Work** **Chapter 1: General information on the different types and uses of renewable energies:** (1 session) 1. Presentation of the different forms of energy 2. Energy sources 3. Conversion of primary energies 4. Global energy context 5. Environmental impact 6. Applications of renewable energies 7. Different renewable energy systems **Chapter 2: Photovoltaic solar** (3 sessions + 2 Application sessions) 1. Solar energy 2. Operation of a photovoltaic system 3. Production process of a cell 4. Different photovoltaic systems and applications 5. Norms and standards 6. Sizing of a PV system (autonomous or connected to the grid) **Chapter 3: Concentrated solar** (1 session) Objective: explain the difference between PV power plants and solar concentrators **Chapter 4: Wind energy** (2 sessions + Application) **Chapter 5: Waste recovery** (2 sessions + Application) 1. Production of biogas from organic waste 2. Production of electricity from waste 3. Different application and environmental impact **Chapter 6: The different forms of energy storage (Pumped Energy Transfer Station and storage with molten salt)** (1 sessions + tutorials) During this course we explain how the Pumped Energy Transfer Station works, so the hydraulic system will be studied
Study and examination requirements and forms of examination	Format: Written Mid-term Exam (40%) + Final Exam (60%)
Media employed	Course Material (Hard/ Soft copy) for classroom & Online (Moodle ULT) Video projection
Reading list	Books and handouts, websites, scientific papers

U.5.2 Environment & Plant Engineering

Bioresources recovery

Module designation	**Environment & Plant Engineering**
Module level, if applicable	3rd year of chemical engineering
Code, if applicable	U. 5.2
Subtitle, if applicable	-
Courses, if applicable	- **Bioresources recovery**
Semester (s) in which the module is taught	-Semester 1 (S1)
Person responsible for the module	Dr Khalil ZAGHDOUDI
Lecturer	Phd. Feriel REZOUGA
Language	French
Relation to curriculum	Professional module (compulsory), (S1)
Type of teaching, contact hours	Lecture, 9 hours of classroom course 12 hours Project
Workload	Total 51 hours/semester (30 hours of Self-Study/semester)
Credit points	2 credits
Requirements according to the examination regulations	- Minimum attendance rate: 80% of the total contact hours >20 % of nonattendance = elimination for exams
Recommended prerequisites	Thermodynamics, Mass& Energy Balance, industrial heterogenous catalysis, Boprocess engineering, chemical reactors.

Module objectives/intended learning outcomes	**Objectives :** 1. Presentation of tools for designing and implementing industrial processes that meet the challenges of sustainable development. 2. Assess the benefits, opportunities, and challenges of bioresources in today's economy 3. Understand the variety of technologies currently employed and under development for production of bioenergy and bioproducts from biomass and algae 4. Comprehend the life cycle of products derived from bioresources and the green supply chain **Learning Outcomes:** Students will be able to : 1. Use of renewable materials from biomass, improvement of the eco-compatibility of processes. 2. Development of industrial synthesis strategies taking into account all sustainability criteria. 3. Develop critical thinking about the socio-economic aspects of the bioeconomy

Content	**Classroom Lecture and Guide Work** **Section 1 (9 hours of contact classroom course/Semester)** **Chapter 1:** Presentation of the notions of plant chemistry **Chapter 2:** Plant chemistry and concepts ranging from biomass to biomaterials via platform molecules 1. Biomass, 2. Biofuels, 3. Lignocellulose pre-treatments, 4. Biosourced platform molecules, 5. Other biosourced molecules of interest, **6.** Biomaterials**.** **Chapter 3:** Bioenergy recovery 1. Conversion technology: bio-ethanol 2. Enhancement on bioenergy recovery from crop residue by using hydrothermal pretreatment 3. Conversion technology: bio-gasification 4. Conversion technology: Bio-Diesel 5. Hydrolysis. Biomass conversion: Biochemical conversion 6. Anaerobic digestion (biogas production from organic waste and wastewater). 7. Algal biofuels(Growth/harvest rates, transesterification) **Section 2 (12h of classroom Project workshop /Semester)** Students are divided into groups of 4 students. A project will be assigned to students group early in the semester. The students will be asked to develop a project plan and will work on project throughout the course. Students groups will work on a given project from the list below **Project topic :** **Proposal 1 :** -Anaerobic digestion of carbon rich sewage sludge for methane production **Proposal 2 :** -Production of acetic acid by fermentation of fruit cannery waste with acetic bacteria **Proposal 3:** Production of xanthan gum by microbial biosynthesis (reactor) on molasses.
Study and examination requirements and forms of examination	Format: Written Mid-term Exam (30%) + Oral Presentation (20%) Project+ Final Exam (50%)
Media employed	Course Material (Hard/ Soft copy) for classroom & Online (Moodle ULT) Video projection

Reading list	Books and handouts, websites, scientific papers -Chimie verte, chimie durable, Sylvain Antoniotti, Ellipse, 2013 -Génie des procédés durables, M. Poux, P. Cognet, et Ch. Gourdon, Dunod, 2010 -Introduction to Biomass Energy conversions, Sergio Capareda, CRC Press, 2013 -Biofuels and Bioenergy, Processes and Technologies, Sunggyu Lee, T.Y Shah, CRC Press, 2012. -Sustainability through biobased Chemistry, R. Chapas, CRC Press, 2017. - Biomass for renewable energy, fuels, and chemicals. D.L. Klass, Academic Press, http://www.sciencedirect.com/science/book/9780124109506 - Algae for Biofuels and Energy, M.A. Borowitzka, N.R. Moheimani,http://www.springer.com/br/book/9789400754782.

.5.2 Environment & Plant Engineering

Process Plant Engineering

Module designation	**Environment & Plant Engineering**
Module level, if applicable	3ndyear of chemical engineering
Code, if applicable	U.5.3
Subtitle, if applicable	-
Courses, if applicable	- **Process Plant Engineering**
Semester (s) in which the module is taught	-Semester 1 (S1)
Person responsible for the module	Dr Khalil ZAGHDOUDI
Lecturer	Phd. Hatem HOUCINE
Language	French
Relation to curriculum	Professional module (compulsory), (S1)
Type of teaching, contact hours	Lecture, 21 hours of classroom course
Workload	Total 42 hours/semester (21 hours of Self-Study/semester)
Credit points	1.5 credits
Requirements according to the examination regulations	- Minimum attendance rate: 80% of the total contact hours >20 % of nonattendance = elimination for exams
Recommended prerequisites	Fluid mechanic, thermodynamic, operations units, Applied Process optimization, Mass & Energy Balance, Applied heat transfer, Applied thermodynamic, Simulation ASPEN
Module objectives/intended learning outcomes	**Objectives :** 1. Knowledge of process utilities such as demineralization of water, steam generation, steam distribution and cooling water, which is essentially required for working in any chemical or related industry. 2. Gain Knowledge about differents problems encountred during chemical process. **Learning Outcomes:** Students will be able to : 1. Calculate the requirements of water and air and their applications as utilities 2. calculate the steam requirement and its applications as utility 3. Evaluate and apply the various risk assessment methods in industries.

Content	**Classroom Lecture and Guide Work** I. Water process utilities **1.** Source of water **2.** water Impurities **3.** Tomporary hardness/ Permanent Hardness **4.** Estimation of hardness by EDTA Method **5.** Water boilers problems **6.** Scale and sludge **7.** Zeolit Process **8.** Lime Soda process **9.** Ion exchage process **10.** Mixed bed deionezer Process II. Steam, Steam generation and steam distrubution **1.** Formation of steam at a constant pressure from water. **2.** Temperature vs total heat graph during steam formation **3.** Important terms for steam **4.** Enthalpy – Entropy (h-s) diagram for water and steam or Mollier Chart **5.** Different types of boilers III. Refractories **1.** Definition, classification, properties, characteristics **2.** General method of manufacturing of refractories **3.** Failure of refractories IV. Insulation **1.** Characteristics, properties, classification V. Refrigerants and Cooling Water VI. Introduction, classification of refrigerants **1.** Important refrigerants **2.** Selection of refrigerants **3.** Construction and working of cooling towers
Study and examination requirements and forms of examination	Format: Written Mid-term Exam (40%) + Final Exam (60%)
Media employed	Course Material (Hard/ Soft copy) for classroom & Online (Moodle ULT) Video projection
Reading list	-Vasandhani, V. P., and Kumar, D. S, Heat Engineering, Metropolitan Book Co. Pvt. Ltd. (2009). -Crowl, D.A. and Louvar, J.F., Chemical Process Safety-Fundamentals with Applications, Prentice Hall, (2002). - Sanders, R. E. Chemical Process Safety-Learning from Case Histories, Oxford (2005). -Chemical Plant Utilities. Sathiyamoorthy Manickkam .Lambert Academic PublishingISBN: 978-3-659-97828-9 (2016). - Plant Utilities by Dr. Mujawar, Nirali Prakashan Publication.

U.5.3 Industrial Manufacturing

Industrial process under high pressure

Module designation	**Industrial Manufacturing**
Module level, if applicable	3nd year of chemical engineering
Code, if applicable	U.5.3
Subtitle, if applicable	-
Courses, if applicable	- **Industrial process under high pressure**
Semester (s) in which the module is taught	-Semester 1 (S1)
Person responsible for the module	Dr Khalil ZAGHDOUDI
Lecturer	Phd. Khalil ZAGHDOUDI
Language	English
Relation to curriculum	Professional module (compulsory), (S1)
Type of teaching, contact hours	Lecture, 42 hours of classroom course
Workload	Total 63 hours/semester (21 hours of Self-Study/semester)
Credit points	2.5 credits
Requirements according to the examination regulations	- Minimum attendance rate: 80% of the total contact hours >20 % of nonattendance = elimination for exams
Recommended prerequisites	Fluids mechanic, thermodynamic, Advanded separation process, Applied Process optimization, Mass & Energy Balance, Applied heat transfer, Applied thermodynamic, physical chemistry. Chemical reactors. Industrial heterogenous catalysis.
Module objectives/intended learning outcomes	**Objectives :** 1. Describe the thermodynamic fundamentals ofseparation processes with supercritical fluids 2. Discuss parameters for processes optimization with supercritical fluids. 3. Describe the thermodynamic fundamentals of separation processes with supercritical fluids **Learning Outcomes:** Students will be able to : 1. Understand of the influences of pressure on properties of compounds, phase equilibria 2. Apply high pressure concept in the complex process design. 3. Discuss parameters for optimization of processes with supercritical fluids.

Content	**Classroom Lecture and Guide Work-Industrial process under high pressure**

Chapter I : Introuction

1. Influence of pressure on fluids propreties
2. Influence of pressure on heterogeneous equilibria
3. Influence of pressure on transport processes

Chapter II: Process under high pressure

1. Absorption
2. Pressure swing adsorption
3. Air distillation
4. Gases liquifaction

Chapter III: Supercritical state

1. Phase diagram of a pure substance
2. Density around the critical point
3. Influence of temperature on solubility
4. Main supercritical fluids
5. Supercritical fluids propreties

Chapter IV: Supercritical fluids as solvents

1. Cleaning & purification
2. Supercritical fluids in reacting systems
3. Gas extraction
4. Imprenation
5. Formulation
6. Dyeing
7. Reaction at high pressure

Chapter V: Industrial Processes

1. Hydrations Reaction
2. Oxidation Reaction,
3. Supercritical water oxidation (SCWO)
4. Haber-Bosch-Process,
5. Polymerizations Reaction ;
6. Methanol-synthesis
7. Pyrolysis,
8. Hydrocracking;
9. Wet air
10. Linde Process,
11. De-Caffeination Process,
12. Petrol and Bio-Refinery Processes
13. Biofuel and Biodiesel Production under high pressure
14. Enzyme Catalysis
15. Feeding and removal of solids, transport within the reactor
16. Materialsprocessingusingsupercriticalfluids

Chapter VI :Supercritical Fluids Extraction (SFE)

1. Advantages and disadvantages
2. Implementation of supercritical extraction Process
3. Treatment of solid matrices
4. Liquid mixtures
5. Energy aspects of the semi-batch extraction process
6. Choice of operating conditions for extraction
7. Solubility in supercritical CO_2
8. Use of co-solvents
9. Industrial applications

Study and examination requirements and forms of examination	Format: Written Mid-term Exam (40%) + Final Exam (60%)
Media employed	Course Material (Hard/ Soft copy) for classroom & Online (Moodle ULT) Video projection
Reading list	- G. Brunner: Gas Extraction. An Introduction to Fundamentals of Supercritical Fluids and the Application to Separation Processes. Steinkopff, Darmstadt, Springer, New York, 1994. - Industrial High Pressure Applications: Processes, Equipment, and Safety.Rudolf Eggers.ISBN: 978-3-527-32586-3. (2012) - High Pressure Process Technology: Fundamentals and Applications.A. Bertucco, G. Vetter . Volume 9,ScienceDirect. (2001). - High-Pressure Processing: Fundamentals, Misconceptions, and Advances. (2019). DOI: 10.1016/B978-0-08-100596-5.22949-1. -Industrial High Pressure Processing of Foods: Review of Evolution and Emerging Trends. (2012). DOI: 10.17265/2159-5828/2012.10.001. -Present and Future of High Pressure Processing.Francisco Barba, Carole Tonello-Samson, Eduardo Puértolas, María Lavilla. (2020). ISBN: 9780128164051. - Hydrothermal and Supercritical Water Processes. (2014). Gerd Brunner. Volume 5. SienceDirect. - Supercritical Fluid Extraction of Nutraceuticals and Bioactive Compounds.Jose L. Martinez. (2008). ISBN 9780367577629.

U.5.3 Industrial Manufacturing

Risk Analysis & Process Safety

Module designation	**Industrial Manufacturing**
Module level, if applicable	3rd year of chemical engineering
Code, if applicable	U. 5.3
Subtitle, if applicable	-
Courses, if applicable	- **Risk Analysis & Process Safety**
Semester (s) in which the module is taught	-Semester 1 (S1)
Person responsible for the module	Dr Khalil ZAGHDOUDI
Lecturer	Phd. Mounir MANSOUR
Language	French
Relation to curriculum	Professional module (compulsory), (S1)
Type of teaching, contact hours	Lecture, 27 hours of classroom course/semester 15 hours of project workshop/semester
Workload	Total 77 hours/semester (35 hours of Self-Study/semester)
Credit points	3 credits
Requirements according to the examination regulations	- Minimum attendance rate: 80% of the total contact hours >20 % of nonattendance = elimination for exams
Recommended prerequisites	Chemical reaction, mathematics, Kinetics reaction, Thermodynamics, Heat transfer, applied statistics, Chemical Reactors, Control & Regulation, mass transfer, ASPEN, HYSYS.

Module objectives/intended learning outcomes	**Objectives :** 1. Be able to perform a risk analysis on a complex industrial system 2. To sensitize students to the concepts of thermal stability of substances, thermal runaway, operating conditions (real-time simulation) and process safety (risk analysis methods). 3. Know how to simulate an industrial process on a large real-time software (Aspen plus, Aspen Hysys dynamic) in order to predict any process drifts **Learning Outcomes:** Students will be able to : 1. Identify and quantify different types of risks presented by a chemical process, 2. Know about different risk analysis methods, 3. Acquire a methodology to understand risk analysis on an industrial scale, 4. Know how to make a chemical process safe by validating its operational integrity (start-up, steady state, shutdown of the installation) using hazard analysis methods (HAZOP method, cause tree, butterfly knot...). 5. Be able to implement environmental management

Content	**Classroom Lecture and Guide Work** Section 1 (27 hours of contact classroom course/ Semester) **Chapter I: Introduction** 1: The Bhopal case 1-1: the ecosystem of a chemical industry 1-2: the legal framework of a chemical industry 1-3: the ethical framework of the profession of chemical engineer 2: General and specific objectives of the course **Chapter II: the basics of thermal safety** 1: Reminders on thermochemistry, kinetics and heat transfer 2: The Power of a Chemical Reaction 3: The cooling power of a reactor 3: Energy balance on a reactor **Chapter III: thermal runaway** 1: Semenov diagram 2: Parametric sensitivity 3: Evolution of pressure under adiabatic conditions 4: Giygas' scenario 5: Severity assessment 6: Probability assessment 7: The criticality of a process **Chapter IV: The risk of gas phase explosion** 1: Characteristics of flammable gas mixtures 1- 1: Flammability and fire triangle 1- 2: Explosive limits of a gas 1- 3: Explosive limits of a mixture of fuel gases 1- 4: Estimation of the CMO 1- 5: Effect of temperature and pressure 2: Characteristics and effects of an explosion 2- 1: Modes of explosion propagation 2- 2: Characteristic quantities of an explosion 2- 3: Factors influencing the regime and the violence of an explosion 2- 4: Calculation of damage by the TNT equivalent method 3: Prevention by action on flammable gases and vapours 3- 1: Ventilation 3- 2: Inerting 3- 3: Inerting-ventilation **Chapter V: Risk analysis methods** 1: The fault tree 2: The LOPA Method 3: The HAZOP **Section 2 : Project (15 hours of classroom workshop/Semester)** Students are divided into groups of 4 students. A project will be assigned to students group early in the semester. The students will be asked to develop a project plan and will work on project throughout the course. Students groups will work on a given project from the list below

	Project topic: **Proposal 1 :** Distillation column quantitative risk assessment. **Proposal 2 :** Hazopstudyof a fixedbedreactorfor MTBE synthesis **Proposal 3 :** Dustexplosionassessmentwithin a pharmaceutical industry **Proposal 4** : Safety level optimization in an oil refinery laboratory
Study and examination requirements and forms of examination	Format: Written Mid-term Exam (40%) + Oral presentation Project (10%)+Final Exam (60%)
Media employed	Course Material (Hard/ Soft copy) for classroom & Online (Moodle ULT) Video projection
Reading list	1- Control and monitoring of chemical batch reactors, Caccavale, Fabrizio, New York,2011, 2- Guidelines for hazard evaluation procedures,Hoboken, N.J. : Wiley-Interscience, c2008, 3- Guidelines for pressure relief and effluent handling systems, New York, N.Y. : The Institute.

U.5.3 Industrial Manufacturing

Safety Modelling

Module designation	**Industrial Manufacturing & Safety**
Module level, if applicable	3nd year of chemical engineering
Code, if applicable	U.3.3
Subtitle, if applicable	-
Courses, if applicable	- **Safety Modelling**
Semester (s) in which the module is taught	-Semester 1 (S5)
Person responsible for the module	Dr Khalil Zaghdoudi
Lecturer	Mr. Baha EDDINE GHARBI
Language	English
Relation to curriculum	Professional module (compulsory),
Type of teaching, contact hours	21 hours practical workshop/ Semester and 21 hours of Project.
Workload	Total 77 hours/semester (21 hours of Self-Study/semester)
Credit points	2.5 credits
Requirements according to the examination regulations	- Minimum attendance rate: 80% of the total contact hours >20 % of nonattendance = elimination for exams
Recommendedprerequisites	Thermodynamic, Fluid mechanics, Applied thermodynamic, Chemical Engineering operations. Chemical engineering reaction
Module objectives/intended learning outcomes	**Objectives:** 1. Introduce PHAST and SAFETI software to students 2. Understand the modelling techniques used **Learning Outcomes:** Students will be able to: 1. Use PHAST and SAFETI modulization Tools, 2. Modelling the consequence with PHAST DNV 3. Modelling the frequency with SAFETI DNV/ Reliability Workbench 4. Calculate the individual and societal risk with SAFETI DNV.

Content	<u>Section 1 : 21 hours of Workshop on PHAST DNV and SAFETI DNV in Laboratory:</u> **Exercise 1: General introduction** I.1 Introduction to PHAST and SAFETI DNV software I.2 The main characteristics of PHAST and SAFETI DNV I.3 Comparison between PHAST DNV and SAFETI DNV I.4 Defining the basic Key word in safety process I.5 Modeling different consequence with PHAST DNV I.6 Modeling different Frequency with SAFETI DNV / Reliability Workbench **Exercise 2: Hazard identification** II.1 General II.2Preliminary Hazard Analysis (PHA) II.3 Hazard and Operability study (HAZOP) II.4Hazard Identification study (HAZID) **Exercise 3: Consequence modelling** III.1 Flash fire III.2 Jet fire III.3 Pool fire III.4 Vapor cloud explosion III.5 Flammablegas dispersion **Exercise 4: Frequency analysis** IV.1 General IV.2 Calculate leak frequency: (Part count Method) IV.3 Modeling the frequency and identify the possible outcome and probability: (Event trees analysis). **Exercise 5: Risk determination** V.1 General V.2 Applications V.2.1 Determine the individual risk V.2.1.1Determine the Location Specific Individual Risk(LSIR) V.2.1.2Modeling the Location Specific Individual Risk (LSIR) V.2.1.3 Calculate the Individual Risk Per Annum (IRPA) V.2.2Determine the societal risk V.2.2.1 Determine the Potential Loss of Life (PLL) V.2.2.2 Determine the F/N curve <u>Section 2 : 21 hours of workshop project in laboratory/Semester</u> Students are divided into groups of 3 students. A project will be assigned to each students group early in the semester. The students will be asked to develop a project plan and will work on project throughout the course. Students groups will work on a given project from the list below **Project Topic :** **Proposal 1:** Quantitative Risk Assessment (QRA) of EL BORMA natural gas receiving facility: Hazard identification, consequence modelling, frequency analysis and risk determination & assessment of the processing plant. **Proposal 2 :** Economic Optimizationof an industrial Security System of benzene Separation in a petroleum fraction.

	Proposal 3 : Safety Hazards Associated with Oil and Gas Extraction Activities. Hazard identification, consequence modelling, frequencyanalysis and risk determination & assessment of the processing plant. **Proposal 4 :** Installation of a firefighting unit in DJBEL GROUZ CPF: Plant sitting, water and foam requirements calculation, firefighting network hydraulic simulation, equipment sizing and economic analysis of the firefighting unit. **Proposal 5 :** Design of Safety System and Management in Petrochemical Industry
Study and examination requirements and forms of examination	Format: Written Manuscript (30%) + Oral Presentation Project (70%)
Media employed	Course Material (Hard/ Soft copy) for classroom & Online (Moodle ULT) Video projection Practical Work on PHAST DNV, SAFETI DNV software in Laboratory Industrial Visit to Tunisian Society of Refining Industries (STIR).
Reading list	- https://www.dnv.com/software/services/phast/index.html -https://www.dnv.com/software/products/phast-safeti-products.html

Elective Unit

U.5.4 Medicinal Chemistry (Elective UNIT 1)

Innovative Trends in Formulation

Module designation	**Industrial Manufacturing**
Module level, if applicable	3rd year of chemical engineering
Code, if applicable	U. 5.4
Subtitle, if applicable	-
Courses, if applicable	- **Innovative Trends in Formulation**
Semester (s) in which the module is taught	-Semester 1 (S5)
Person responsible for the module	Dr Khalil ZAGHDOUDI
Lecturer	Phd. Ghazi TABKA
Language	French
Relation to curriculum	Professional module (elective),
Type of teaching, contact hours	Lecture, 36 hours of classroom course/ Semester 6 hours of Practical Workshop in Lab/ semester
Workload	Total 77 hours/semester (35 hours of Self-Study/semester)
Credit points	3 credits
Requirements according to the examination regulations	- Minimum attendance rate: 80% of the total contact hours >20 % of nonattendance = elimination for exams
Recommended prerequisites	Physical chemistry, unit Operations, Fine chemistry, pharmacology, kinetics reaction.
Module objectives/intended learning outcomes	**Objectives :** 1. Train the students with respect to basics of monophasics, biphasics, topical formulation, aerosols, 2. Explain principles of preformulations and basic formulation considerations formonophasic liquid orals and emulsions suspensions, suppositories and aerosols **Learning Outcomes:** Students will be able to : 3. Describe unit operations, large scale manufacturing and layout for monophasic, biphasics,semisolids, suppositories and aerosols 4. Conceptualize and develop monophasic liquid oral and topical formulations.

Content	**Classroom Lecture and Guide Work** **Chapter I : I. FUNDAMENTAL ASPECTS OF DRUGS** 1. Classification of Drugs 2. Nomenclature of Drugs 3. Rules of Drug Nomenclature **Chapter II : Solubilization techniques** **Chapter III : Monophasics** 1. Preformulation 2. Formulation 3. Quality Control 4. Layout design and unit operations **Chapter IV : Biphasic – Suspensions& Biphasic – Emulsions** 1. Preformulation 2. Technical Principles and Stabilization 3. Formulation Development 4. Evaluation 5. Large scale manufacturing and packaging with focus on equipment 6. Layout design and unit operations **Chapter VI : Ointments** 1. Preformulation 2. Formulation 3. Evaluation 4. Large scale manufacture and packaging with focus onequipment 5. Layout design and Unit operations **Chapter VI : Gels & Suppositories** 1. Preformulation 2. Formulation 3. Evaluation 4. Large scale manufacture and packaging with focus onequipment 5. Layout design and Unit operations **Chapter VII: Aerosols** 1. Containers and Propellents 2. Formulation of aerosols 3. Evaluation of aerosols **6 hours of Practical Workshop in Laboratory- New trends in Formulation** 1. Capsules: Formulation and manufacture and control of paracetamol capsules 2. Emulsion: Formulation of an oil/water emulsion through the determination of the critical HLB
Study and examination requirements and forms of examination	Written Mid-term Exam (25%) + Practical Exam (25%) + Written Final Exam (50%)
Media employed	Course Material (Hard/ Soft copy) for classroom & Online (Moodle ULT) Video projection Practical Workshop in Laboratory

Reading list	-Wilson and Gisvold's Textbook of Organic Medicinal and Pharmaceutical ... by Charles Owens Wilson, John H. Block, Ole Gisvold, John Marlowe Beale. -The Organic Chemistry of Drug Design and Drug Action by Silverman R. B., 2nd Edn. Academic Press. 2012. -Pharmacologie (2ème édition), M. Moulin et A. Coquerel. MASSON. -Advanced Practical Medicinal Chemistry, Ashutosh Kar, New Age International Ltd. (2004). -Foye's Principles of Medicinal Chemistry by David A. Williams, Thomas L. Lemke, William O. Foye (2008), Kluwer publication. -Remington-The Science And Practice Of Pharmacy (Vol.1& 2), David B.Troy, 21st edition,2006, Lippincott Williams &Wilkins

U.5.4 Medicinal Chemistry (Elective UNIT 1)

Pharmaceutical Standards Protocols

Module designation	**Medicinal Chemistry**
Module level, if applicable	3rd year of chemical engineering
Code, if applicable	U. 5.4
Subtitle, if applicable	-
Courses, if applicable	- **Pharmaceutical Standards Protocols**
Semester (s) in which the module is taught	-Semester 1 (S5)
Person responsible for the module	Dr Khalil ZAGHDOUDI
Lecturer	Phd.
Language	French
Relation to curriculum	Professional module (elective),
Type of teaching, contact hours	Lecture, 42 hours of classroom course/ Semester
Workload	Total 77 hours/semester (35 hours of Self-Study/semester)
Credit points	3 credits
Requirements according to the examination regulations	- Minimum attendance rate: 80% of the total contact hours >20 % of nonattendance = elimination for exams
Recommended prerequisites	-

Module objectives/intended learning outcomes	**Objectives :** 1. Acquire the knowledge regarding the regulatory aspects in the pharmaceutical industries. 2. Know the different competent regulatory authorities globally. 3. Students will explore the global regulatory environment and learn about the importance of international standards and harmonized guidelines in the pharmaceutical and medical device sectors 4. Have an idea on regulatory guidelines and directions framed by the regulatory authorities will be helpful to place the drug products in market for marketing approvals. **Learning Outcomes:** Students will be able to : 1. Understand current issues in the regulatory affairs world from industry-based regulatory affairs professionals and representatives of national regulatory bodies. 2. Describe the global regulatory landscape for medicinal products (pharmaceuticals, biologics and medical devices). 3. Outline the key regulatory documentation required for successful marketing authorizations

Content	**Classroom Lecture and Guide Work** 1. Introduction 2. International regulatory trends in pharmaceutical industry. 3. Role of regulatory affairs department in pharmaceutical organization -Regulatory audits, -Interactions with various other departments, - Single point contact with regulatory agencies 4. Types of regulatory filings for pharmaceutical products 5. Good Manufacturing Practices (GMP) - Tunisia GMP Certification, WHO GMP Certification - ICH guidelines for stability testing and other relevant ones (Q1-Q10). -Quality Assurance and Quality Control – Basic understanding for in-built quality. 6. Documentation- Protocols, Forms and Maintenance of records in Pharmaceutical industry. 7. Governing Regulatory Bodies. - U.S Food & Drug Administration USDMF - Canada Therapeutic Product Directorate DMF - European Medicines Agency (EMEA/ National Authorities) EDMF - European Directorate for Quality of Medicines CEP/COS & Health Care Products. - MHRA – Medicines and Health Care Products Regulatory Agency 8. Registration of medicinal products for human use - Registration procedure - Composition of the registration dossier - Timelines for answering - Request for appeal - Marketing authorizationwithdrawal 9. Processing and its application, Intellectual Property Rights (Patent, Copyright and Trademarks).
Study and examination requirements and forms of examination	Format: Written Mid-term Exam (40%) + Written Final Exam (60%)
Media employed	Course Material (Hard/ Soft copy) for classroom & Online (Moodle ULT) Video projection

Reading list	-Guidelines for Developing National Drug Policies; WHO Publications. - ICH guideline Q12 on technical and regulatory considerations for pharmaceutical product lifecycle management. (2020EMA/CHMP/ICH/804273/2017. Committee for Medicinal Products for Human Use. - Pharmacy and Drug Directorate - Ministry Of Health - Tunisia. MEDICINAL PRODUCTS REGISTRATION GUIDE IN TUNISIA. (2016). - Quality assurance of pharmaceuticals. Good manufacturing practices and inspection. Volume 2. I SBN 978 92 4 154708 6. - Official website of european medicine agency. https://www.ema.europa.eu/en. - Official website of Medicines and Health Care Products Regulatory Agency.https://www.gov.uk/government/organisations/medicines-and-healthcare-products-regulatory-agency.

U.5.4 Medicinal Chemistry (Elective UNIT 1)

Project (Pharmaceutical product design)

Module designation	**-Medicinal Chemistry**
Module level, if applicable	2nd year of chemical engineering
Code, if applicable	U.5.4
Subtitle, if applicable	-
Courses, if applicable	- **Project** (**Pharmaceutical product design)**
Semester (s) in which the module is taught	-Semester 1 (S1)
Person responsible for the module	Dr Khalil ZAGHDOUDI
Lecturer	Phd. Khalil ZAGHDOUDI
Language	French
Relation to curriculum	Professional module (Elective),
Type of teaching, contact hours	21 hours of Practical Project /semester
Workload	Total 51 hours/semester (30 hours of Self-Study/semester)
Credit points	2 credits
Requirements according to the examination regulations	- Minimum attendance rate: 80% of the total contact hours >20 % of nonattendance = elimination for exams
Recommended prerequisites	Organic Chemistry & Catalysis, Structural Organic Chemistry, Structural & Metabolic Biochemistry, Fine chemistry, Chromathographic separation process, Pharmacology.
Module objectives/intended learning outcomes	**Objectives :** 1. Concept of rational drug design 2. To familiarize future engineers with the methods of analyzing and design of drugs. 3. Have knowledge on purification and analysis techniques of active compunds. **Learning Outcomes:** Students will be able to : 1. Propose a chemical mechanism of a pharmaceutical active compound synthesis 2. Analytical validation and purification of obtained product.

Content	**<u>21 hours of Project workshop/Semester</u>** The purpose of these projects is to continue learning project management and teamwork through the development of a technological innovation project. By technological project, we mean a study intended to develop an idea initiated by a "customer= Supervisor". This must proceed from an innovation process aimed at creating "a new product, a new service, a new good. Students are divided into groups of 3 to 4 students. They are confronted with real professional and managerial situations,. Students groups will work on a given project during the semester in order to carry on an innovative process from the beginning to the end. **<u>Project Topic</u>** **Proposal 1 :** Choice of physicochemical identification tests according to the structure, Chemical identification reactions (functional groups, etc.) Development of a dosage protocol Determination of active substance content for theophylline-Ethylenediamine. **Proposal 2 :** Implementation of comparative assay methods from different pharmacopoeias (European, USP) applied to the control of beta-lactam. Establishment of a dosing protocol for the active substance by the students. Dosage of water in drugs. **Proposal 3:** Thin Layer Chromatography Technique and Purification of commercially available drugs/Synthesized Compounds by Column Chromatography. **Proposal 4:** Preparation of Acid / Basic Salts of Drugs and Evaluation of their Physicochemical Properties. (Benzilic Acid & Sodium Benzoate) **Proposal 5:** Synthesis & Purification of Benzimidazole. **Proposal 6:** Synthesis of Anthranilic Acid. **Proposal 7:** Synthesis of Sulfanilamide. **<u>Project Working Steps:</u>** 1. Search for documentation sources - Study of the state of the art and analysis of resources (patents, publications, internet) 2. Writing 3. Use of process simulation software 4. Teamwork awareness 5. Design Product/Protocol 6. Propose and find scientific several way of designing a pharmaceutical product.
Study and examination requirements and forms of examination	Format: Oral Presentation (50%) + Redaction of manuscript (50%)

Media employed	Course Material (Hard/ Soft copy) for classroom & Online (Moodle ULT) Video projection Practices on ChemDraw software, oral presentation
Reading list	Books and handouts, websites, https://www.perkinelmer.com/fr/category/chemdraw ChemDraw Tutorials Documents & Video

U.5.4Material Sciences (Elective UNIT 2)

Processing on Polymers & Composites

Module designation	**Industrial Manufacturing**
Module level, if applicable	3rd year of chemical engineering
Code, if applicable	U. 5.4
Subtitle, if applicable	-
Courses, if applicable	- **Processing on Polymers & Composites**
Semester (s) in which the module is taught	-Semester 1 (S1)
Person responsible for the module	Dr Khalil ZAGHDOUDI
Lecturer	Pr. Mohamed JAZIRI
Language	French
Relation to curriculum	Professional module (compulsory),
Type of teaching, contact hours	Lecture, 36 hours of classroom course/ Semester 6 hours of Practical Workshop in Lab/ semester
Workload	Total 77 hours/semester (35 hours of Self-Study/semester)
Credit points	3 credits
Requirements according to the examination regulations	- Minimum attendance rate: 80% of the total contact hours >20 % of nonattendance = elimination for exams
Recommended prerequisites	Organic chemistry, Polymers synthesis, thermodynamics, Fluid mechanics, Physical chemistry of polymers.
Module objectives/intended learning outcomes	**Objectives :** 1. Impart an understanding of the manufacturing science and engineering of polymers and polymer composites 2. Classification of engineering materials and processing techniques, the structure and mechanical properties of plastics, thermoplastics and thermosets, the various processing techniques of polymers. **Learning Outcomes:** Students will be able to : 1. Differentiate between polymer processes 2. Formulate composites 3. Show the particularities of shaping polymers and composites 4. Choose the methods of characterization by light scattering and by microscopy. 5. Make the link between certain usage properties, the formulation and operating conditions of the production process

Content	**Chapter I. Characterization of polymers in the molten state** **Chapter II. Thermomechanical characterization of polymer and composite materials in the solid state** 1. Dynamic Mechanical Analysis (DMA) 2. Thermal Mechanical Analysis (TMA) 3. Differential Scanning Calorimetry (DSC) 4. Determination of the VICAT and HDT point 5. Fourier transform infrared 1600 6. Shore A and D hardness 7. Plastics traction machine 8. KINEMAT torque follower 9. TROMBOMA viscosity tracker **Chapter III. Polymer and composite implementation** 1. UV aging enclosure 2. Inflating extrusion line 3. Compounding line 4. Composite press 5. 60 ton injection Molding machine 6. Billion bi-material injection Molding machine **Chapter IV. Optical properties of polymer materials** 1. CR 30 colorimeter 2. Laboratory press 3. Reflectometer **Practical workshop in Laboratory -Processing of polymers and composites (6 hours of practical workshop in laboratory)** Analysis and test on a plastic material. Determination of tensile properties ***Objectives :*** Understand the general principles for determining the tensile properties of plastics under defined conditions. Tensile testing is used to study the tensile behavior of test specimens and for the determination of tensile strength, tensile modulus and other aspects of stress / tensile strain relationships under defined conditions.(Chemistry Technical Center: CTC Laboratory)
Study and examination requirements and forms of examination	Written Mid-term Exam (25%) + Practical Exam (25%)+ Written Final Exam (50%)
Media employed	Course Material (Hard/ Soft copy) for classroom & Online (Moodle ULT) Video projection Practical Workshop Industrial Visit (Solution Composite Industry)

Reading list	-Plastic Materials and Processing: A. Brent Strong, Prentice Hall, ISBN 0-13-021626-7. -Handbook of Composites: S.T. Peters, ISBN 978-1-4615-6389-1. -https://www.worldoftest.com/hdtvicat-heat-deflection-testers. -Carbon ContainingPolymerComposites. Springer Link. (2019).ISBN: 978-981-13-2688-2. - Composite Materials: Engineering and Science: F.L. Mathews and R.D. Rawlings, CRC press, 084930251X - Brydson J.A., "Plastic Materials", Elsevier 8th Edition. (2016). - Polymer Processing: Principles and Design, 2nd Edition by Donald G. Baird, Dimitris I. Collias, Wiley-Interscience. (2014).

U.5.4 Material Sciences (Elective UNIT 2)

Molding and design

Module designation	**Material Sciences**
Module level, if applicable	3rdyear of chemical engineering
Code, if applicable	U. 5.4
Subtitle, if applicable	-
Courses, if applicable	- **Molding and design**
Semester (s) in which the module is taught	-Semester 1 (S5)
Person responsible for the module	Dr Khalil ZAGHDOUDI
Lecturer	Pr. Mohamed JAZIRI
Language	French
Relation to curriculum	Professional module (Elective),
Type of teaching, contact hours	Lecture, 42 hours of classroom course/semester
Workload	Total 77 hours/semester (35 hours of Self-Study/semester)
Credit points	3 credits
Requirements according to the examination regulations	- Minimum attendance rate: 80% of the total contact hours >20 % of nonattendance = elimination for exams
Recommended prerequisites	Material sciences, polymers & composites, physical chemistry, solid chemistry. Micro- and nanostructured products.Chemical engineering Reaction.

Module objectives/intended learning outcomes	**Objectives :** 1. Knowledge of general mold design, cavity feeding patterns and cooling function in the molding cycle. 2. Understand the problem of plastic shrinkage and its influence on the quality of the items to be produced 3. Technical and economic control of the various molding processes. **Learning Outcomes:** Students will be able to : 1. Ability to understand the processing techniques 2. Ability to design a mold for a product 3. Ability to understand the importance of mold in product development. 4. Approach the thermal phenomena that condition the cycle time, the operating cost and the profitability of the molding process. 5. Approach the modeling of flows relating to the molding of polymers gradually during the filling and compacting phases 6. Use Mold-flow (injection simulation) and Poly-flow (flow simulation) software for industrial parts.

Content	Session 1 (27 hours of classroom contact hours) **Chapter I: General information on the molding of plastic materials.** **Chapter II: Injection molding of thermoplastics** 1. Injection machines and systems. 2. Different types of injection and moulds. 3. Study of the injection molding cycle. 4. Study of P, V, T and shrinkage diagrams. 5. Influence of the main implementation parameters. 6. Modeling of flows. 7. Analysis of filling and compaction. 8. Analytical calculations. 9. Practical design of injection tools. 10. Rules of thumb for building an injection mold. 11. Cooling function: exchanges between the material and the mold and with the heat transfer system. **Chapter III : Injection blowing of hollow bodies** 1. Principle of the technique 2. Design of machines, molds and parts. 3. Structure with several materials. 4. Shape, volume and dimensions of the blank. 5. Preform injection mold. 6. Blow mold. 7. Temperature regulation. 8. Bi-oriented blowing. **Chapter IV : Injection of thermosets** 1. Main injected materials. 2. Machine design. 3. Injection devices for powder and paste compounds. Tool architecture. 4. Flow of the thermosetting material. 5. Choice of the injection point, the joint plane and placement of the remains. 6. Execution of the mold and heating system. **Chapter V: Compression molding** 1. Raw material, pretreatment and composition of the thermosetting material. 2. Role of heat during molding & Fluidity. 3. Relationship between pressure, temperature and molding time. 4. Transfer molding. **Chapter VI : Thermoforming** 1. Processed materials and application of the method. 2. Technical solutions used on forming machines. Design of thermoformed parts. 3. Implementation and form of the object. **Chapter VII: Rotational molding** 1. Materials used. 2. Characteristics of objects. 3. Design of machines and tools. 4. Case of polycaprolactam (PA 6) in rotational molding. **Session 2 (14 hours of Laboratory workshop/semester)**

	Poly-flow: Anisothermal flow of a molten polymer - Isothermal blowing - Swelling and Recirculation in a die. Case of Newtonian and Viscoelastic fluids; Co-extrusion Spinning. - Flow in the channel of an extrusion screw. - Mold-flow: Positioning of the injection point, calculation of injection pressures, optimal injection speed, temperature profile and prediction of the solid sheath.
Study and examination requirements and forms of examination	Format: Written Mid-term Exam (25%) + Practical Exam (25%)+ Written Final Exam (50%)
Media employed	Course Material (Hard/ Soft copy) for classroom & Online (Moodle ULT) Video projection Laboratory Practical
Reading list	Books and handouts, websites, https://www.ansys.com/products/fluids/ansys-polyflow

U.5.4Material Sciences (Elective UNIT 2)

Project (Innovent Materials)

Module designation	**Material Sciences**
Module level, if applicable	3rd year of chemical engineering
Code, if applicable	U. 5.4
Subtitle, if applicable	-
Courses, if applicable	- **Materials Science**
Semester (s) in which the module is taught	-Semester 1 (S5)
Person responsible for the module	Dr Khalil ZAGHDOUDI
Lecturer	Phd. Malek ATYAOUI
Language	French
Relation to curriculum	Professional module (Elective),
Type of teaching, contact hours	21 hours of Project/semester
Workload	Total 51 hours/semester (30 hours of Self-Study/semester)
Credit points	2 credits
Requirements according to the examination regulations	- Minimum attendance rate: 80% of the total contact hours >20 % of nonattendance = elimination for exams
Recommended prerequisites	Material sciences, polymers & composites, physical chemistry, solid chemistry.Micro- and nanostructured products.Chemical engineering Reaction.
Module objectives/intended learning outcomes	**Objectives :** 1. Preparation of inorganic solids, host-guest chemistry, ionic liquids and its significance. 2. Understanding composites and their industrial applications. **Learning Outcomes:** 1. Select the materials and properties appropriate for a specific application. 2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors. 3. The ability to design components, systems, and processes for materials and metallurgical engineering based on engineering, economy, energy, environment, and sustainability.

Content	**(21 hours of workshop session/ Semester)** The purpose of these projects is to continue learning project management and teamwork through the development of a technological innovation project. By technological project, we mean a study intended to develop an idea initiated by a "customer= Supervisor". This must proceed from an innovation process aimed at creating "a new product, a new service, a new good". Students are divided into groups of 3 to 4 students. They are confronted with real professional and managerial situations,. Students groups will work on a given project during the semester in order to carry on an innovative process from the beginning to the end (concept/simulate/design). **Project topic :** **Proposal 1 :** Study of porosity in aeronautical laminated composite materials. **Proposal 2 :** Elaboration of materials / porous materials (Sol-gel, hydrothermal, microwave). **Proposal 3 :** Preparation of silver nano material **Proposal 4 :** Preparation of urea-formaldehyde resin **Proposal 5 :** Elaboration of material for gas storage and catalytic applications **Proposal 6 :** Mesoporous/microporous silica based materials, functionalized hybrid materials and its applications. **Proposal 7 :** Applications of nano-structured materials in targeted drug delivery/pharmaceutical applications/industrial applications. **Proposal 8 :** Elastoplastic analyzes of progressive deformation on primary piping
Study and examination requirements and forms of examination	Format: Oral Presentation (50%) + Redaction of manuscript (50%)
Media employed	Course Material (Hard/ Soft copy) for classroom & Online (Moodle ULT) Video projection
Reading list	Books and handouts, websites,

U.5.5Management & Corporate Culture

Quality Control & Standards

Module designation	**Management & Corporate Culture**
Module level, if applicable	3rdyear of chemical engineering
Code, if applicable	U. 5.5
Subtitle, if applicable	-
Courses, if applicable	- Quality Control & standards
Semester (s) in which the module is taught	-Semester 1 (S5)
Person responsible for the module	Dr Khalil ZAGHDOUDI
Lecturer	Phd. Marouen BEN HAJ YAHIA
Language	French
Relation to curriculum	Professional module (compulsory),
Type of teaching, contact hours	Lecture, 21 hours of classroom course
Workload	Total 42 hours/semester (21 hours of Self-Study/semester)
Credit points	1.5 credits
Requirements according to the examination regulations	- Minimum attendance rate: 80% of the total contact hours >20 % of nonattendance = elimination for exams
Recommended prerequisites	No recommended prerequisites
Module objectives/intended learning outcomes	**Objectives:** 1. Understand ISO 9000 standard requirements 2. Understand all aspects of the certification process **Learning Outcomes:** Students will be able to : 1. Differentiatebetween the different aspects of certification and quality control, 2. Set up a quality system process, 3. Work on all aspect of ISO9000 certifications projects

Content	**Chapter I. Introduction** 1. Definition 2. Key principles for quality management. 3. Juran's Spiral of Quality. **Chapter II - Define the ISO quality assurance standard** 1. What is ISO? 2. The ISO name. 3. What 'international standardization' means. 4. Advantage of ISO standards for society. 5. ISO and developing countries. 6. Where can I find out about the standards? 7. Who funds ISO. 8. Certify to sell. **Chapter III - ISO 9000 certification process Implementation** **Chapter IV - Preparation required before certification** **Chapter V - Certification of companies in Tunisia** **Chapter VI - Build your quality system** 1. Quality assurance plan (pack): a partnership tool. 2. Definition and concepts. 3. Role of quality assurance. 4. Organization of the quality system.
Study and examination requirements and forms of examination	Format: Written Mid-term Exam (40%) + Final Exam (60%)
Media employed	Course Material (Hard/ Soft copy) for classroom & Online (Moodle ULT) Video projection
Reading list	BOERI, Daniel. « Maîtriser la qualité : Tout sur la certification et la qualité totale (2e éd) ». Ed : Maxima, 2003. Website TUNAC www.tunac.tn ISO 9001:2008, ISO 17025 : 2005. https://www.iso.org/fr/iso-9001-quality-management.html

U.5.5 Management & Corporate Culture

Startup

Module designation	**Management & Corporate Culture**
Module level, if applicable	3rd year of chemical engineering
Code, if applicable	U. 5.5
Subtitle, if applicable	-
Courses, if applicable	- **Startup**
Semester (s) in which the module is taught	-Semester 1 (S5)
Person responsible for the module	Dr Khalil ZAGHDOUDI
Lecturer	Miss. Soukeina TOUITI
Language	French
Relation to curriculum	Professional module (compulsory),
Type of teaching, contact hours	21 hours Seminar/supervised Projects
Workload	Total 42 hours/semester (21 hours of Self-Study/semester)
Credit points	1.5 credits
Requirements according to the examination regulations	- Minimum attendance rate: 80% of the total contact hours >20 % of nonattendance = elimination for exams
Recommended prerequisites	No recommended prerequisites
Module objectives/intended learning outcomes	**Objectives:** 1. Understand all steps to start a project 2. Understand all financial and legal issues **Learning Outcomes:** Students will be able to : 1. Be familiar with the terms and formalities necessary for setting up a business, 2. Use all the knowledge on process, legal and economic issues to start up a project

Content	**Chapter I GENERAL INTRODUCTION** 1. Definition and objectives of a project 2. Type of projects 3. Typology of companies 4. Actors involved in a project 5. The economic and financial environment of the company 6. The Business model canvas (BMC): Application and workshop **Chapter II: Stages of business creation** 1. The profile of the creator and entrepreneurial culture 2. Identification of a project: idea and opportunities 3. Market research 4. Feasibility study 5. Profitability study: Economic and financial evaluation 6. Financing Plan 7. Study of the preliminary implementation project **Chapter III: Preparation of the project** 1. The market and commercial means 2. Means of production 3. Human resources 4. Space requirements 5. Development of a business plan **Chapter IV: Financial evaluation methods of a project** 1. The cost of the investment 2. The instruments and methods for calculating the profitability of the project 3. Capitalization and discounting 4. Net Present Value Method 5. Internal rate of return method 6. Choice and decision criteria 7. Case studies **Chapter V: The method of financing companies** 1. Self-financing 2. Equity 3. Debt 4. The industrial promotion fund, SICAR, spin-off 5. Project financing scheme **Chapter VI: The LEGAL file of the company** 1. Legal formalities and constitution of a company: 2. Statutes, trade register, agreement (API, CEPEX,…) Tax registration number, publication in the official journal,… 3. Capital formation and payment of shares **Chapter VII: Environment and support for business creation in Tunisia.** 1. Business environment and export support 2. Administrative and technical support 3. Supervision and training of young promoters, business incubators 4. Role of Tunisian National Institutions in promoting business Startup: API, APIA, BTS, BFPME,...

Study and examination requirements and forms of examination	Format: Evaluation & Oral Presentation (100%)
Media employed	Course Material (Hard/ Soft copy) for classroom & Online (Moodle ULT) Video projection
Reading list	- Casteran S., Créer son entreprise, PRAT, 2008. - Frogier V., La création d'entreprise de A à Z, Dunod, 2007. - Le Guern P., Isabello, J., Créer son entreprise, Jacob-Duvernet, 2006. - Montbello M., Création d'entreprise : Connaissances et Analyses Stratégiques, Economica, 2004. - Moschetto B. L., Le Business Plan, Economica, 3ème édition, 2005. - Portella A., Trouver Une Idée de Création d'Entreprise, Studyrama, 2009. - Stutely R., Concevoir un Business plan Efficace, Village Mondial, 2ème édition, 2005. - Triquère C., Le Grand livre de la Création d'Entreprises, Studyrama, 2009. - Verstaete T., Saporta., B., Création d'Entreprise et Entrepreneuriat, Editions de l'ADREG, 2006.

U.5.5 Management & Corporate Culture

Supply Chain Management

Module designation	**Management & Corporate Culture**
Module level, if applicable	3rd year of chemical engineering
Code, if applicable	U. 5.5
Subtitle, if applicable	-
Courses, if applicable	- **Supply Chain Management**
Semester (s) in which the module is taught	-Semester 1 (S5)
Person responsible for the module	Dr Khalil ZAGHDOUDI
Lecturer	Phd Amine OUALHA
Language	French
Relation to curriculum	Professional module (compulsory),
Type of teaching, contact hours	21 hours seminar/ projects
Workload	Total 51 hours/semester (30 hours of Self-Study/semester)
Credit points	2 credits
Requirements according to the examination regulations	- Minimum attendance rate: 80% of the total contact hours >20 % of nonattendance = elimination for exams
Recommended prerequisites	Lean Management, Industrial Production Management.
Module objectives/intended learning outcomes	**Objectives:** 1. Organize, manage and monitor the functioning of the global logistics chain 2. Collaborative Logistics **Learning Outcomes:** Students will be able to : 1. Choose an external logistics provider (distributor, transporter, subcontractor, supplier) 2. Model and solve logistics network problems

Content	***Seminar Sessions:*** I. Introduction to supply chain management: 1- Introductionto Supply Chain Management 2- Stakes ofthe SCM 3- SCM decisionsandprocess 4- 3 pointsto finish II. Selectionofproductionsites • Introduction • Procedureforselecting a newsite • Methodforselecting potential sites: Multicriteriaapproachof Brown and Gibson III. Flow management: 1- Introduction 2- Notionsrelatedtoflowmanagement 3- Wilson model 4- Newspaper vendor model at. Integrated supplychain (single-actor case) b. Supply Chain not integrated (two players) vs. Coordinationofthe Supply Chain bybuying back the un sold quantity 5- Single-period flow control 6-Heuristics of Silver-Meal 7-Case of 2 levels (1 supplierand 1 seller) 8-An applicationforeachmodel IV. Logisticscostsandvaluecreation • Introduction • Nature ofcosts • Cost determination by activity (ABC) • Choice ofmeansoftransport a. Description oftheelementsof a modern transportsystem b. Advantages and disadvantages of the various modes of transport c. Cost modeling and options analysis **Project (14 hours of Self-Study/ Semester)** Students are divided into groups of 4 students. A project will be assigned to each students group early in the semester. The students will be asked to develop a project plan and will work on project throughout the course. Students groups will work on a given project from the list below **Project topic :** **Proposal 1 :** Modelling the enablers and alternatives for sustainable supply chain management **Proposal 2** : The application of Halal in supply chain management
Study and examination requirements and forms of examination	Format: Written Mid-term Exam (40%) + Oral Presentation Project (10%) + Final Exam (50%)

Media employed	Course Material (Hard/ Soft copy) for classroom & Online (Moodle ULT) Video projection
Reading list	-Analysis, Design, Second edition, John Wiley and Sons. GLOVER, F., D. KLINGMAN et N. -SHAPIRO, J.F. (2001). Modeling the Supply Chain, Duxbury, and Thomson learning. -TOMPKINS, WHITE, BOZER et TANCHOCO (2003). Facilities Planning, Wiley. -An Introduction to Sustainable Transporta on Policy, Planning and Implementa on. By Preston L. -Schiller, Eric C. Bruun and Jeffrey R. Kenworthy. April 2010. ISBN 9781844076659 -Closed-Loop Supply Chains: New Developments to Improve the Sustainability of Business -Pracces. Edited by Mark E. Ferguson and Gilvan C. Souza, Auerbach Publica ons 2010. Print ISBN: 978-1-4200-9525-8. eBook ISBN: 978-1-4200-9526-5