الجمهورية الجزائرية الديمقراطية الشعبية
Algerian Democratic and People's Republic
وزارة التعليم العالي والبحث العلمي
Ministry of Higher Education and Scientific Research
اللجنة البيداغوجية الوطنية لميدان العلوم والتكنولوجيا
National Pedagogical Committee for the Science and Technology sector

Harmonized Academic Master's Program

National Programme

Updated 2025

DOMAIN	FIELD	SPECIALTY
Science And Technology	***Process Engineering***	***Materials Process Engineering***

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I – Master's Program Fact Sheet

Access conditions

Sector	harmonized master	Licenses granting access at the master's	Ranking according to the license compatibility	Coefficient assigned to
Process Engineering	***Materials Process Engineering***	Process Engineering		**1**
		Materials Engineering		**2**
		Materials Chemistry (SM)		**3**
		Materials Physics (SM)		**3**
		Inorganic Chemistry (SM)		**4**
		Other licenses in the (ST)		**5**

II – Semester organization sheets for the specialty courses

Semester 1: Materials Process Engineering

Teaching Unit	Subjects	Credits	Coef-ficient	Weekly hourly volume			Hourly Volume Semestriel (15 weeks)	Additional work in Consultation (15 weeks)	Evaluation Mode	
	Titled			**Course**	**TUT**	**PW**			**Continuous Assessment**	**Exam**
Fundamental UE Code : UEF 1.1 Crédits : 8 Coefficients : 4	**Class and Structure of Materials**	4	2	1h30	1h30		45h00	55h00	40%	60%
	Physical Chemistry of Silicates	4	2	1h30	1h30		45h00	55h00	40%	60%
Fundamental UE	**Technical Thermodynamics**	4	2	1h30	1h30		67h00	82h30	40%	60%
Code : UEF 1.2	**Crystallography**	4	2	1h30	1h30		45h00	27h00	40%	60%
Crédits : 10	**Materials Characterization**	2	1	1h30			22h30			100%
Coefficients : 5										
Methodological UE Code : UEM 1.1 Crédits :11 Coefficients : 7	**Instrumentation and Measurement**	4	2	1h30		1h30	45h00	55h00	40%	60%
	Electrochemical Methods	4	2	1h30		1h30	45h00	55h00	40%	60%
	Advanced Python Programming	2	2	1h30		1h30	45h00	55h00	40%	60%
Discovery UE Code : UED 1.1 Crédits : 2 Coefficients : 2	**Material of your choice**	1	1	1h30			22h30	2h30		100%
Total 1st semester		**30**	**17**	**15H00**	**6h00**	**4h00**	**375h00**	**375h00**		

Teaching Unit	Subjects	Cr ed its	Coef- ficient	Weekly hourly volume			Hourly Volume Semestriel (15 weeks)	Additional work in Consultation (15 weeks)	Evaluation Mode	
	Titled			Course	TUT	PW			Continuous Assessment	Exam
Fundamental UE Code : UEF 2.1 Crédits : 18 Coefficients : 9	**Unit Operations II**	4	2	1h30	1h30		45h00	55h00	40%	60%
	Transformation techniques	4	2	1h30	1h30		67h30	82h30	40%	60%
	Processing Techniques	2	1	1h30			22h30	27h30		100%
	Phase Diagrams	4	2	1h30	1h30		45h00	55h00	40%	60%
	Industrial Furnaces Technology	4	2	1h30	1h30		45h00	55h00	40%	60%
Methodological UE Code : UEM 2.1 Crédits : 9 Coefficients : 5	**Aging and Degradation of Materials**	4	2	1h30		1h30	45h00	27h30	40%	60%
	Surfaces and Interfaces	3	2	1h30		1h00	37h30	37h30	40%	60%
	Practical Work: Materials Processing	2	1			1h30	22h30	55h00	100%	
Transversal UE Code : UED 2.1 Crédits : 3 Coefficients : 3	**Adherence to ethical standards and rules of integrity**	1	1	1h30			22h30	2h30		100%
	Elements of Applied AI	**1**	1	1h30			22h30	2h30	40%	60%
Total 2nd semester		**30**	**17**	**15h00**	**06h00**	**4h00**	**375h00**	**375h00**		

Teaching Unit	Subjects	Credits	Coef-ficient	Weekly hourly volume			Hourly Volume Semestriel (15 weeks)	Additional work in Consultation (15 weeks)	Evaluation Mode	
	Titled			Course	TUT	PW			Continuous Assessment	Exam
Fundamental UE Code : UEF 2.1.1 Crédits : 10 Coefficients : 5	**Porous and Dispersed Media**	4	2	1h30	1h30		45h00	55h00	40%	60%
	Polymeric and Composite Materials	6	3	3h00	1h30		67h30	82h30	40%	60%
Fundamental UE Code : UEF 2.1.2 Crédits : 8 Coefficients : 4	**Glass Technology**	4	2	1h30	1h30		45h00	55h00	40%	60%
	Ceramics and Binders Technology	4	2	1h30	1h30		45h00	55h00	40%	60%
Methodological UE Code : UEM 2.1 Crédits : 9 Coefficients : 5	**Application of Materials in Pollution Control**	2	1			1h30	22h30	27h30	100%	
	Modeling and Process Optimization	3	2			1h00	37h30	37h30	40%	60%
	Application of Catalytic Materials to the Chemical Reactions	2	1	1h30			22h30	27h30		100%
	Life cycle analysis of materials and calculation of the economic balance	2	1	1h30			22h30	27h30		100%
Transversal UE Code : UET 2.1 Crédits : 3 Coef : 3	**Documentary research and thesis design**	1	1	1h30			22h30	2h30		100%
	Chemical reserve engineering	2	2	1h30	1H30 (WORKSHOP)		45	5	40%	60%
Total 3nd semester		**30**	**17**	**18h00**	**4h30**	**2h30**	**375h00**	**375h00**		

General guidelines on the choice of introductory subjects:

1- Glassware and ceramics
2- Servomechanisms and Regulation
3- Materials for optics, electronics and optoelectronics
4- Nanotechnology and nanomaterials
5- Biocompatible materials
6- Management of Technological Resources
7- Welding and NDT
8- Glassware and ceramics
9- Servomechanisms and Regulation
10- Materials for optics, electronics and optoelectronics
11- Nanotechnology and nanomaterials
12- Biocompatible materials
13- Management of Technological Resources
14- Welding and NDT

Semester 4

An internship in a company or research laboratory, culminating in a dissertation and a defense.

	VHS	Coeff	Credits
Personal Work	550	09	18
Internship in a company or in a laboratory	100	04	06
Seminars	50	02	03
Other (Framework)	50	02	03
Total Semester 4	750	17	30

This table is provided for informational purposes only.

Evaluation of the Master's Final Year Project

- Scientific value (Jury's assessment) /6
- Writing the Dissertation (Jury Assessment) /4
- Presentation and answering questions (Jury's assessment) /4
- Supervisor's assessment /3
- Presentation of the internship report (Jury evaluation) /3

III - Detailed program by subject for Semester S1

Semester 1
Teaching Unit: UEF 1.1.1
Subject: Class and structure of materials
VHS: 67h30 (Lectures: 1.30h00, Tutorials: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

The knowledge and characterization of solids with perfectly controlled shapes, sizes and structures has become essential, due to their widespread use in industry: catalysts for cracking or hydrocarbon synthesis, fillers introduced into elastomers or paints, pigments, adsorbents used for purification or chemical analysis (molecular sieves, adsorbents for chromatography), hydraulic binders (concrete), powders intended for the preparation of emulsions (emulsions of products for agricultural treatments)...

The aim of the course is to provide the student with a clear overview of the major classes of materials, their physicochemical characteristics, and to be able to define their limits of use.

Recommended prior knowledge:

.

General chemistry, organic chemistry, fundamental thermodynamics

Contents of the material:

Chapter 1. Inorganic Materials **(5 Weeks)**

I- Introduction: cohesion in crystalline solids, physical properties of materials.
II- Metals and alloys
III Ceramics and glass
IV- Damage to materials over time

Chapter 2. Organic Materials **(5 Weeks)**

I- Presence of polymers in the environment
II- Classification of synthetic and natural polymers
III Position of polymeric materials in relation to ceramic metals
IV Polymer morphology (semi-crystalline and amorphous)

Chapter 3. Classification of polymers by their properties **(5 Weeks)**

I- Thermal properties
II- Mechanical Properties
III- Electrical Properties
IV- Optical Properties

Assessment method: Continuous assessment: 40%; Examination: 60%.

Bibliographical references:

1- Microstructure and properties of materials.
Collective Press of the National School of Bridges and Roads (ENPC) Presses de l'école nationale des Ponts et Chaussées (ENPC)
2- Properties of natural materials
3- Materials (4-volume set) - AMC, special edition
Steel - Wood - Terracotta - Glass, Collective Groupe Moniteur

Semester 1

Teaching Unit: UEF 1.1.1
Subject : Physical Chemistry of Silicates
VHS: 45h00 (Lectures: 1h30, Tutorials: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

Understanding and assimilating the physico-chemical mechanisms involved in the transformation of matter under the effect of temperature (interactions between particles, sintering mechanisms, melting, clinkerization…), interaction with the environment, hydration of hydraulic binders…

On the other hand, they will be given a detailed view of the chemistry, microstructure and performance of structural materials (cementitious, ceramic, vitreous…).
Also, some research questions about these materials will be introduced.

Recommended prior knowledge:

- Concepts of crystallography -
Structures and defects - Crystallography -
- Phase diagrams - Microstructure of inorganic materials
- Potential and chemical equilibria. Sintering, melting, microstructure

Contents of the material:

Chapter 1. Theoretical Foundations **(2 weeks)**

1. Thermodynamic Principles:

2. Chemical Potential

3. Chemical Equilibrium and the Solubility

Product

4. Phase Diagrams

5. Undersaturation and Dissolution

6. Supersaturation and precipitation (nucleation - growth)
7. Oswald's Maturation

Chapter 2. Silicon Element **(4 Weeks)**

1 Introduction, Origin, Abundance

2. Silicon Preparation (elemental laboratory, industrial production)

3. Physico-chemical properties,

4. Crystallographic properties (Micro and nanostructures)

5 Simple elements based on Si

6. Silicon compounds (Silica, Silanes, Metallic silicides, Silicones)

Chapter 3. Silicates **(4 Weeks)**

1. Aluminosilicates

2. Synthesis and transformation of silicates

* Dry route

* Action of water

2. Crystalline structures of silicates

Tectosilicate, Phyllosilicate, Inosilicate (single or double chain polymer) Cyclosilicate (polymer in a ring), Sorosilicate (dimer), Nesosilicate (monomer)

Chapter 4. Silica **(5 Weeks)**

1 Physical Chemistry

* Polymorphic Transformations
* Melting, devitrification, vaporization
* Chemical reactions

2. Artificial preparation of SiO_2

3 Different forms of silica (Quartz, Tridymite, Cristoballite, Other forms)

4. Stability zones of different silica varieties

5 Uses

Assessment method: Continuous assessment: 40%; Examination: 60%.

Bibliographical references: (If possible)

-Gilles Mertens, Jan Elsen, Dominique Laduron and Raymond Brulet, Mineralogy of the calcium-silicate phases present in ancient mortars from Tournai , ArcheoSciences, journal of Archaeometry

-Jean WYART, "SILICATES", EncyclopædiaUniversalis.
URL: http:// www.universalis.fr/ encyclopedie/ silicates/

-Jean-Pierre Mercier and Ernst Maréchal, Treatise on materials, vol. 13: Polymer chemistry: syntheses, reactions, degradations, Lausanne, Presses polytechniques et universitaires romandes, 1996.

Semester 1

Teaching Unit: UEF 1.1.2

Subject: Applied Thermodynamics

VHS: 67h30 (Lectures: 3h00, Tutorials: 1h30)

Credits: 6

Coefficient: 3 Teaching

objectives:

The applied thermodynamics course aims to provide Process Engineering students with scientific knowledge of turbomachinery, psychrometrics, and air humidification. Furthermore, it enables the application of thermodynamics to irreversible processes and to engine cycles, refrigeration systems, and heat pumps.

Recommended prior knowledge: General chemistry, thermodynamics and inorganic chemistry from previous semesters.

Contents of the material:

Chapter 1. Turbomachinery I.1 **(3 Weeks)**

Pumps

I.2 Fans

I.3 Compressors

I.4 Turbines

Chapter 2 : Psychrometry II.1 **(4 Weeks)**

Gas-vapor mixture and adiabatic saturation

II.2 Psychrometric Chart

II.3 Air Humidification

Chapter 3. Thermodynamic Cycles III.1 Carnot **(4 Weeks)**

Cycle and Efficiency

III.2 Engine and refrigeration cycles

III.3 Heating, air conditioning and ventilation systems.

III.4 Heat pumps and cogeneration

Chapter 4. Thermodynamics of Irreversible Processes IV.1 Conservation of **(4 Weeks)**

Energy in Open Systems

IV.2 Entropy balance of an open system

IV.3 Physical and chemical exercise

IV.4 Exergy losses of an open system

Assessment method: Continuous assessment: 40%; Examination: 60%.

Bibliographic references:

Smith, EB, Basic, Chemical Thermodynamics, 2nd ed., Clarendon Press, Oxford, 1977. Stanley I. Sandler, Chemical and Engineering Thermodynamics, Wiley, New York, 1977. Lewis GN, Randal M., Thermodynamics, Mac Graw Hill

Hougen OA, Watson KM, Chemical process principles, Vol II: Thermodynamics, John Wiley and sons Brodyanski V., Sorin M., Le Goff P. The efficiency of industrial processes, exergy analysis and optimization, Amsterdam, Elsevier, (1994). Wuithier, P., Petroleum, Refining and Chemical Engineering, Technip Edition 1972 Abbott M; Theory and Applications of Thermodynamics, Schum Series, Paris 1978 Kireev, V. Course in Physical Chemistry, Mir Edition, Moscow 197

Semester 1
Teaching Unit: UEF 1.1.2
Subject : Crystallography
VHS: 45 hours (Lectures: 1 hour 30 minutes, Tutorials: 1 hour 30 minutes)
Credits: 4
Coefficient: 2

Teaching objectives:

Knowledge of the general laws governing the geometry of crystals and macroscopic recognition of the main families of materials.

Recommended prior knowledge: Physics, general and inorganic chemistry from previous semesters and structure of matter.

Contents of the material:

Chapter 1. Basic concepts of symmetry **(3 Weeks)**

Chapter 2. Structures and Groups 2. Group Structure
3. Point Groups and Bravais Lattices 4. 3D Symmetry Groups
5. Representation of groups **(3 Weeks)**

Chapter 3. Molecular Stacking **(3 Weeks)**

Chapter 4. Common Structures **(3 Weeks)**
a) Structure of NaCl
b) Structure of CsCl
c) Zinc blende (ZnS) structure
d) Rutile structure

Chapter 4. Network Faults **(3 Weeks)**

a) Stoichiometric solids
b) Non-stoichiometric solids

Assessment method: Continuous assessment: 40%; Examination: 60%.

Bibliographical references:

• J.-J. Rousseau, 'Geometric Crystallography and X-ray Crystallography with Solved Exercises', Masson, Paris 1995. • J.-J. Rousseau, Geometric Crystallography and X-ray Crystallography, Dunod 2000. • E. Mooser, 'Introduction to Solid State Physics', Presses polytechniques et universitaires romandes, Lausanne 1993.

Semester 1
Teaching Unit: UEM1.1
Subject : Materials Characterization
VHS: 10:30 PM (Class: 1 hour 30 minutes)
Credits: 2
Coefficient: 1

Teaching objectives:

Training in common physical methods of analysis in quality control and research laboratories, specializing in materials analysis.

Acquire knowledge and skills in evaluating and controlling the surface properties of materials

Recommended prior knowledge: Physical Chemistry, Analytical Chemistry

Contents of the material:

Chapter 1. Thermal Analyses . **(3 Weeks)**

Differential Thermal Analysis (DTA)
Thermogravimetric analysis (TGA)
Differential Scanning Calorimetry
(DSC)

Chapter 2. Microscopic and Porosity Analyses **(4 Weeks)**

1. Scanning Electron Microscopy (SEM)
2. Transmission electron microscopy (TEM)

Chapter 3. Diffractometric Analyses

- X-ray diffraction **(4 Weeks)**

Chapter 4. Spectroscopic Methods - UV-Visible Spectroscopy **(4 Weeks)**

- Atomic absorption spectroscopy
- FTIR Spectroscopy

Assessment method : Examination: 100%

Bibliographical references:

1. Thermal Analysis (3rd Edition),
2. W. Wendlandt, John Wiley and Sons (USA), 1986.
3. Thermal Analysis, B. Wunderlich, Academic Press (USA), 1990.
4. Thermal Characterization of Polymeric Materials, EA Turi, Academic Press (USA), 1981.
5. Thermal Analysis of Foods, VR Harwalkar, Elsevier (UK), 1990.
6. Thermal kinetic TG-analysis of metal oxalate complexes, Li Jun & co, ThermochimicaActa, 406 (2003) 77-87.
7 - J. Grimblot, Surface analysis of solids by electron and ion spectroscopies, Masson (1995)
8 - JW Niemantsverdriet, Spectroscopy in catalysis, VCH (1993)

Semester 1

Teaching Unit: UEM 1.1

Subject: Instrumentation and Measurement

VHS: 45 hours (class: 1:30, practical: 1:30)
Credits: 4
Coefficient: 2

Teaching objectives:

The student will learn the principles of Instrumentation and Regulation (Metrology, Process Control, Physical Quantities, Passive, Active, Integrated Sensors, Characteristics, Transmitter and Standards and Functional Diagram).

Practical exercises (depending on the technical capabilities of the institution)

Recommended prior knowledge:

General mechanics, electricity, basic elements of electronics.

Content of the material:

Chapter 1 : Introduction **(1 week)**
Chapter 2 : Different Types of Measurements **(3 weeks)**
- 2.1 Measurement of Acoustic and Vibratory Quantities
- 2.2 Measurement of hydraulic and pneumatic quantities
- 2.3 Measurement of mechanical quantities
- 2.4 Measurement of thermal quantities
- 2.5 Measurement of dimensional quantities
- 2.6 Measurement of electrical quantities
- 2.7 Measurement of optical quantities
- 2.8 Measurement of volume, mass, time

Chapter 3 : Non-destructive testing **(1 week)**
Chapter 4 : Organization, methods and measurement techniques **(2 weeks)**
Chapter 5 : Calibration **(1 week)**
Chapter 6 : Signal processing **(3 weeks)**
Chapter 7 : Data processing **(2 weeks)**
Chapter 8: Introduction to experimental design **(2 weeks)**

Assessment method:

Continuous Assessment: 40%, Examination: 60%.

Bibliographical references :

1. "Physical measurements and instrumentation: Statistical and spectral analysis of measurements, sensors", Barchiesi, Dominique, Paris, Ellipse, 2003.
2. "Sensors in industrial instrumentation", Asch, Georges, Paris, Dunod, 1999.
3. RJ Goldstein, "Fluid Mechanics Measurements", 1983.

Semester 1

Teaching Unit: UEM1.1

Subject : Electrochemical Methods of Analysis

VHS: 45h00 (Lectures: 1h30, Tutorials: 1h30)

Credits: 4

Coefficient: 2

Teaching objectives:

Recommended prior knowledge:

-Solution chemistry, basic concepts in electrochemistry.

Contents of the material:

Chapter 1. Voltammetry **(4 Weeks)**

Chapter 2. Potentiometry **(4 Weeks)**

Chapter 3. Amperometry. **(4 Weeks)**

Chapter 4. Coulometry **(3 Weeks)**

Assessment method: Continuous assessment: 40%; Examination: 60%.

Bibliographical references:

1. Allen J. Bard, Electrochemistry: principles, methods and applications, Masson, 1983.
2. Fabien Miomandre, Said Sadki, Pierre Audebert, Electrochemistry from concepts to applications, Dunod, 2005.

Semester 1

Teaching Unit: UEM1.1
Subject 1: Materials Characterization

VHS: 3:00 PM (TP: 1 hour)
Credits: 1
Coefficient: 1

Teaching objectives:

Training in the physical methods of analysis commonly used in testing and research laboratories. Presentation at the laboratory level (practical work) of some modern methods used (depending on the equipment capabilities of the institution) in materials analysis. Acquire knowledge and skills in evaluating and controlling the surface properties of materials

Recommended prior knowledge: Physical Chemistry, Analytical Chemistry

Contents of the material:

Practical Exercise 1. Thermal Analysis Differential thermodynamic analysis (DTA) Thermogravimetric analysis (TGA)
Differential Scanning Calorimetry (DSC)
. Pyrolysis analysis (pyrolysis coupled with GCMS, Py-GCMS)
Differential Thermomechanical Analysis (DMA)

Practical Exercise 2. Microscopic and Porosity Analyses

1. Scanning electron microscopy (SEM)
2. Transmission electron microscopy (TEM)
3. AFM
4. BET
5. Porosimetry

TP 3. Diffractometric analyzes

Lab 4. Spectroscopic Methods

TP 5. New methods for characterizing polymeric materials

Assessment method: Continuous assessment: 100%;]

Bibliographical references:

1. *Thermal Analysis (3rd Edition),*
2. *W. Wendlandt, John Wiley and Sons (USA), 1986.*
3. *Thermal Analysis, B. Wunderlich, Academic Press (USA), 1990.*
4. *Thermal Characterization of Polymeric Materials, EA Turi, Academic Press (USA), 1981.*
5. *Thermal Analysis of Foods, VR Harwalkar, Elsevier (UK), 1990.*
6. *Thermal kinetic TG-analysis of metal oxalate complexes, Li Jun & co, ThermochimicaActa, 406 (2003) 77-87.*
7 - *J. Grimblot, Surface analysis of solids by electron and ion spectroscopies, Masson (1995)*

8 - *JW Niemantsverdriet, Spectroscopy in catalysis, VCH (1993)*

Semester: S1

Teaching Unit: UET 1.1.1

Subject: Advanced Programming in Python

VHS: 45h00 (Lecture 1h30, Practical 1h30)

Credits: 2

Coefficient: 2

Objectives of the subject:

Skills targeted:

- Use of computer tools for the acquisition, processing, production and dissemination of information.
- Skills in Python and project management,
- Skills in automation and data visualization.

Objectives:

- To deepen mastery of the Python language and introduce students to the basics of data analysis and artificial intelligence.
- Acquire a solid foundation in computer science.
- Learn to program in Python and Excel .
- Master task automation
- Master project management software

Required materials:

- A computer with Python installed,
- Python libraries: NumPy, Pandas, Scikit-learn, Matplotlib, os.listdir, os.path.exists os.mkdir, os.rmdir, Matplotlib, Seaborn, Plitly, Request, Beautiful Soup, Tkinter, PyQT, …
- Tensorflow, PyTorch.

Prerequisite: Python programming.

Content of the material:

Chapter 1: Review of Python Programming (2 Weeks)

1. Introduction: Basic computer concepts and digital tools, installation of Python.
2. Introduction to the concept of an operating system: Roles, types (Linux, Windows, etc.) Priority management,
3. Introduction to computer networks (Principles, IP address, DNS, internet,)
4. Basic programming: Interactive mode and script mode, Variables, data types, Operators. Conditional structures and loops (if, for, while).
5. Essential functions and elements: Predefined functions and function creation. Standard modules (math, random). Strings, lists, basic database manipulation.
6. Files, Lists, Tuples, Dictionaries,
7. Exercises:
   - Python learning exercises
   - Exercises using the libraries seen in the course (Math, Random, NumPy, Pandas,…)

Chapter 2: Programming and Automation **(4 weeks)**

1. Principles of Task Automation
   - Python libraries for automation
   - working with Excel or CSV files
   - Definitions and examples of automation (sending emails, etc.)
2. File manipulation with Python:

• Use libraries to: ÿ Browse a directory (os.listdir) ÿ Check for the existence of a file or directory (os.path.exists) ÿ Create or delete directories (os.mkdir, os.rmdir) ÿ Visualize data: Matplotlib, Seaborn, Plitly ÿ Request data to interact with Application Programming Interfaces (APIs)
ÿ Beautiful Soup for data scraping ÿ Tkinter, PyQT for visualizing graphical data • Copy or move files with shutil…

• Search, sort and generate simple reports.

• Serialization and Deserialization (Using the pickle module).
• Object serialization and processing of large files (streaming).

3. Exercises :

• Using openpyxl and pandas to read, modify and write Excel files or CSV for: ÿ Creating automatic reports ÿ Automatically extracting data
ÿ …

• Writing scripts to: ÿ process text files (search, sorting) ÿ automate technical calculations ÿ manage simple reports (PDF, Excel)
ÿ …

• Sorting, searching, and insertion sort algorithms • Implementing a search function in a list • File operations • Secure browsing (configuring simple networks, managing passwords)
• …

Chapter 3: Advanced Excel Learning **(2 weeks)**

1. Macro Principles and Creating a Simple Macro,
2. Pivot Tables,
3. Histograms,
4. Bar Charts,
5. Spider Chart,
Etc.

7. Excel **Exercises** … **(2 weeks)**

Chapter 4: Learning GanttProject

1. Introduction to Project Management: • What is a project? • What are the challenges of project management? • GanttProject Interface

2. Tasks (creation, modification, organization)

3. Time management (project start or end dates)
4. Resource Management
5. **Exercises** on Gantt Project

Chapter 5: Advanced Object-Oriented Programming (3 weeks)

1. Code organization: • Custom functions, parameters, return value.
   • Modules, imports and packages.
2. Complex data structures:
   • Lists, tuples and dictionaries: creation, modification, deletion, traversal.
3. Fundamental concepts of Object-Oriented Programming (OOP):
   • Classes, objects, attributes and methods.
   • Public, private and protected attributes.
4. Special methods:
   • **init, str, repr, len.**
5. Advanced concepts:
   • Encapsulation, abstraction, inheritance, polymorphism.
   • Advanced inheritance, decorators, design patterns, metaclasses.
6. **Exercises**

Chapter 6: Introduction to Data for AI (2 weeks)

1. Introduction to Common Datasets in AI:
   • Iris, MNIST, CIFAR-10, Boston Housing, ImageNet.
2. Data preprocessing for Machine Learning:
   • Cleaning, normalization, encoding, separation of data.
   • Cross-validation.
3. Feature Engineering Techniques:
   • Selection, creation of features, dimensionality reduction.
4. Essential libraries for developing AI models:
   • scikit-learn, TensorFlow, Keras, PyTorch
5. **Exercises**

Practical exercises:

Lab 1: Mastering the basics of Python programming

(Control structures, types, loops, simple functions)

1. Introduction

2. Reading and processing text files **3.**

Managing simple reports (PDF, Excel)

TP 02:

Develop a specification for a mini task automation project with Python consisting of automatically identifying and sending reports by email with Python: **1.** Load data from a file (e.g., experimental measurements), **2.** Perform simple statistics on the data (mean, standard deviation with interpretation), **3.** Generate a graph, **4.** Send the result with Python.

TP 03:

1. Programming the dashboard seen in class using Excel.

2. Creating automated Excel spreadsheets , **3.**

Simple macros, **4.**

Conditional formulas, **5.** VLOOKUP.

Practical

Exercise 4: Organizing a Meeting in Ganttproject

1. Create a new project: • Project Name: “Meeting…” • Start Date: Date and time of the meeting • Estimated Duration: Total duration of the meeting

2. Definition of tasks

• Agenda items (each agenda item becomes a task)

• Subtasks: If a point is compound, then create the corresponding subtasks. • Initial and final tasks (for example: "Welcoming participants", "closing of the meeting")

3. Definition of resources:

• Participants (each participant is a resource) • Equipment (computer, data projector…)

4. Estimating durations:

• Duration of each item: time required for each agenda item • Transition time from one item to the next **5.** Creating the Gantt chart: • Visualize the agenda • Identify key items **6.** Track progress in real time (projection of the Gantt chart)

TP 05: Advanced Structures and Code Organization

(Custom functions, dictionaries, modules, and modular organization)

Lab 6: Advanced Object-Oriented Programming in Python

(Encapsulation, inheritance, special methods, simple design patterns)

Lab 07: File Manipulation and Data Analysis

(Reading/ writing files, word processing, introduction to Pandas and NumPy)

Lab 08: Data preparation and processing for artificial intelligence

(Loading AI datasets, cleaning, transformation, feature selection)

Final Project

Title: Analysis and visualization of a dataset + simple predictive model

Skills used: Data reading, OOP, advanced structures, Pandas, Scikit-learn.

(Oral presentation + written report).

Evaluation method:

exam 60% , CC=40%

Bibliography

[1] .E.Schultz and M.Bussonnier (2020): Python for the Humanities and Social Sciences. Introduction to Data Programming. Presses Universitaires de Rennes.

[2] C. Paroissin, (2021): Data science practice with R: arranging, visualizing, analyzing and presenting data. Paris: Ellipses, DL 2021.

[3] .S.Balech and C.Benavent: NLP text minig V4.0, (Paris Dauphine – 12/2019): link: https://www.researchgate.net/publication/337744581_NLP_text_mining_V40_-_une_introduction_-_doctoral_course_program

[4] .Allen B. Downey Think Python: How to Think Like a Computer Scientist, O'Reilly Media, 2015;

[5] .Ramalho, L.. Fluent Python. “O’Reilly Media, Inc.”, 2022;

[6] .Swinnen, G.. Learning to program with Python 3. Editions Eyrolles, 2012;

[7] .Matthes, E. Python crash course: A hands-on, project-based introduction to programming. no starch press, 2019

[8] Cyrille, H. (2018). Learning to program with Python 3. Eyrolles, 6th edition. ISBN: 978-2212675214

[9] Daniel, I. (2024). Learning to code in Python, I read

[10]. Nicolas, B. (2024). Python, from complete beginner to object-oriented programming: Course and exercises Answer key, 3rd edition, Ellipses

[11] . Ludivine, C. (2024). Selenium: Master your functional tests with Python, Eni

Online resources:

- Official Python documentation: docs.python.org
- Python exercises on Codecademy: codecademy.com/learn/learn-python-3
- W3Schools Python Tutorial: w3schools.com/python/

Semester 1

Teaching Unit: UED1.1

SUBJECT : Recycling of materials

VHS: 10:30 PM (Class: 1 hour 30 minutes)
Credits: 1
Coefficient: 1

Teaching objectives:

1- Knowledge of the polluting chemical identity of a waste.
2- Know how to determine the correct disposal method for a given waste in accordance with regulations.
3- Understanding the main processes for treating industrial waste

Recommended prior knowledge: Life cycle and aging of materials.

Content of the material:

1. Definitions of recycling. **(1 week)**
2. Life cycle analysis 3. **(1 week)**

Describe the different possibilities for recycling industrial waste and by-products(2 **weeks)**

4. Criteria for material selection; establishing the different stages of the materials life cycle **(2 weeks)** their problems and impacts, and how.
5. Describe the recycling and recovery processes, including their environmental impact. **(2 weeks)**

6. Household waste collection **(3 weeks)**
7. Waste treatment **(2 weeks)**
8. Manufacturing new materials from waste **(2 weeks)**

Assessment method: 100% exam

References

1- Abrassard C., Aggeri F., "The birth of eco-design, From product life cycle to environmental product management", Responsibility and Environment, no. 25, Jan. 2002

BALET J.-M., Waste Management Handbook, Dunod, 2nd edition, 2008, 248 pages, ISBN 978-2-10-051627-8.

DAMIEN A., Guide to Waste Treatment, Dunod, 4th edition, 2006, 560 pages, ISBN 978-2-10-049597-9

III - Detailed program by subject for Semester S2

Semester 2

Teaching unit: UEF2.1

Subject 1: Unit Operations II

VHS: 45h00 (Lectures: 1h30; Tutorials: 1h30)

Credits: 4

Coefficient: 2

Teaching objectives:

- To acquire basic knowledge in unitary mechanical and diffusional operations, separation and size adjustment involving solids (agglomeration, fragmentation and separation of solids, filtration, crystallization;
- Explain the concepts behind the different operations of separation and adjustment of size and shape;
- To enable the student to choose and size the type of equipment appropriate for a given situation (separator, crusher, mixer...).

Recommended prior knowledge:

Mass transfer, heat transfer, and momentum transfer

Contents of the material:

Chapter I: Thermodynamics Review **(1 Week)**

- Liquid-Vapor Equilibrium
- Phase rule

Chapter II: Agglomeration and Fragmentation Processes of Solids (3 Weeks)

- Agglomeration of solids (Generalities; Agglomeration mechanisms; Agglomeration without compression (granulation); Agglomeration with compression; Coating)
- Fragmentation of solids (Generalities; Conditions and techniques of grinding; Equipment; Grinding energy; Solids separation)

Chapter III: Humidification Operations (3 Weeks)

(Definition of humidity; Concepts of wet-bulb temperature (dry and dew point); Psychrometric chart (Mollier, Carrier, etc.); Unit operations on wet air; Simultaneous transfer of matter and heat; Adiabatic saturation; Isothermal saturation; Dehumidification).

Chapter IV: Drying and Evaporation - **(3 Weeks)**

Drying (Methods of drying solids; Humidity of solids; Drying speed; Drying time; Continuous and discontinuous drying; Common drying technologies; Sizing of a dryer).

Chapter V: Gas-Liquid Contact Towers **(2 Weeks)**

-Cooling towers

- Tower sizing

Chapter VI: Solid-Liquid Separation **(2 Weeks)**

(Membrane separation, Filtration,…)

Assessment method : Continuous assessment: 40%; Examination: 60%

References:

1) **Ernest E. Ludwig,** Applied Process Design For Chemical and Petrochemical Plants Volume 1, Third Edition
2) **Ernest E. Ludwig,** Applied Process Design For Chemical and Petrochemical Plants Volume 2, Third Edition
3) **Ernest E. Ludwig,** Applied Process Design For Chemical and Petrochemical Plants Volume 3, Third Edition
4) **RK Sinnott,** Chemical Engineering, Volume 6, Third edition Chemical Engineering Design

5) **JF Richardson, JH Harker and JR Backhurst,** Chemical Engineering Volume2 Fifth Edition *Particle Technology and Separation Processes*
6) **James G. Speight,** Chemical and Process Design Handbook.

Semester 2

Teaching unit: UEF2.1
Subject 2: VHS Transformation Processes:

67h30 (Lecture: 1h30; Tutorial: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

Understand the fundamental principles of shaping processes (granulation, grinding, drying, etc.) and implementation (formulation, mixing, dosing, handling, etc.).
This subject closely links the understanding of the structure and properties of materials with the development and implementation of materials for industrial purposes. It allows students to follow the various stages of transformation and shaping of a material, whether organic (polymers and composites) or inorganic (glasses, ceramics, metals, binders, etc.), before it is handed over to an engineer. It also enables students to establish a link between the causes and effects of material degradation in order to optimize their uses.

Recommended prior knowledge:

The student must have knowledge of materials chemistry, inorganic chemistry, chemistry

Organic chemistry, polymer chemistry, silicate chemistry, physical chemistry and chemical engineering

(thermodynamics, surface chemistry, chemical kinetics, transfer laws, …)

Content of the material

Chapter I: Concepts of technological processes for manufacturing materials **(3 weeks)**

- Definition of an industrial process
- Concepts of process optimization
- Process influence parameters

- Transition from method to technique to process
- Comparison between laboratory-scale and industrial-scale processes
- Implementation of the industrial process
- Stages in the materials manufacturing process

Chapter II: Typology of processes **(3 weeks)**

• Primary: Shaping from a semi-finished product
• Secondary: Functional surface shaping • Tertiary: Part quality improvement (polishing)

Evaluation method :

Continuous assessment: 40% Exam: 60%

References:

1- **Austin, LG, Klimpel, RR, Luckie, P. T:** Process Engineering of Size Reduction: Ball Milling, Edition: SME, New York, USA, 1984

2- **A. Gupta :** Mineral processing design and operations: An introduction, Edition Lavoisier 2008

3- **RP King:** Modeling and simulation of mineral processing systems, Edition Butterworth- Heinemann 2001

4- **BA Wills :** Will's mineral processing technology: An introduction to the practical aspects of ore treatment and mineral recovery Edition Butterworth-Heinemann 2006

5- **Barin I., Knacke O., and *Kubachewsky,O.,Thermochemical*** Properties of Inorganic Substances, Edition Springer Verlag, Berlin, (1977).

6- **G. Chaussin, G. Hilly** - Metallurgy - Dunod Volume 1: Metallic alloy, Volume 2: metal processing, 1966.

7- **Schönert K.,** Size Reduction (Fundamentals) – Chap 1, in Ullmann's Encyclopedia of Industrial chemistry. Flight. B2: Unit operations I, p. 5.1-5.14. Ed: Vch Verlagsgesellschaft mBh Weinheim (1988)

8- **Pomeran** Y., Wheat: Chemistry and technology, AACC, St Paul USA, (1998).

9- **Buchel. KH, HM Moretto and P.Woditsch.,** Industrial Inorganic Chemistry, John Wiley- VCH verlag, Weinheim (2000).

10- **Buckton** G., Interfacial phenomena in drug delivery and targeting. Drug targeting and delivery, ed. ATFaG Gregoriadis, Harwood academic publishers (1995).

11- **Godet L.,** Fine grinding of talc by opposed air jet, in Chemical Engineering-Process Engineering, National Polytechnic Institute of Lorraine (2001).

12- **Henry Le Chatelier,** "Chemistry of silicates", Edition "A. Hermann et Fils", 1914.

13- **Arnold Lassieur,** " Analysis of silicates ", Edition "Dunod", 1951.

14- **R. Kern,** “Course in structural mineralogy of silicates”, Edition “LMC”, 1958.

15- **Eitel, Wilhelm,** “The Physical Chemistry of the Silicates”, Edition “The University of Chicago Press”, 1954.

16- **Michel-Lévy Albert and Wyart Jean,** " Artificial Reproduction of Silicate Minerals" High Pressure”, Edition “Headquarters of the Geological Society”, 1947.

17- **Marc Carrega ,** Industrial materials - polymer materials, Dunod Edition, June 2000.

18- **Jean-Pierre Cohen,** Polymer: Plastic material, Belin Edition, 2007.

19- **Marc Carrega ,** Plastics - Reference guide, 2nd edition Dunod, October 7, 2009.

20- **Jean Pierre Mercier,** Polymer Chemistry, Syntheses, Reactions, Degradations, 1st year edition, 1993.

21- **Adda Y., Dupouy JM,** “Elements of physical metallurgy”, Documentation Française, Paris 1976.

22- **Bernard J., Michel A., Philibert J., Talbot** J., "General Metallurgy", 2nd edition Masson, Paris 1984

Semester 2

Teaching Unit: UEF 2.1
Subject 1: Shaping Processes

VHS: 10:30 PM (Class: 1 hour 30 minutes)
Credits: 2
Coefficient: 1

Teaching objectives :
Putting into practice the basic methods of shaping materials

Recommended prior knowledge:
- Basic knowledge of general mathematics -
Basic knowledge of physical chemistry and chemical engineering (thermodynamics, surface chemistry, chemical kinetics, transfer laws, etc.)
-Basic knowledge of inorganic and organic chemistry

Content of the material:

Chapter I: Classification of shaping processes **(3 weeks)**

Chapter II : Mixing Powders
Chapter III : Grinding (3 **Weeks) Chapter IV :** Wet Granulation (3 **Weeks) Chapter V** Dry Granulation **Chapter VI** Encapsulation

Example of Metallic Material Forming Processes **(3 weeks)**

-Preparation of raw materials
- Melting process of metallic compounds
- Process of:

a. Forging;
b. Foundry;
c. Sintering;
d. Stamping.

Example of Polymer and Composite Shaping Processes (Shaping of Thermosetting Matrix Composites):
- Industrial processes for the transformation and manufacture of polymers (in bulk, in solution, in emulsion, in suspension, …)
- Solidification and shaping of polymers (Single and twin screw extrusion process: profile extrusion, blow molding, inflation extrusion, hollow body blowing, textile spinning, calendering, thermoforming).
-Molding processes:

a. Low-pressure liquid resin injection molding (RTM); b. Long fiber reinforced reactive resin injection molding (S-RIM);
c. Contact molding;
d. Reaction injection molding (R-RIM); e. Comparison of various shaping and manufacturing processes.

Assessment method : 100% exam

Works

6- ***Austin, LG, Klimpel, RR, Luckie, P.*** **T:** Process Engineering of Size Reduction: Ball Milling, Edition: SME, New York, USA, 1984

7- ***A. Gupta :*** Mineral processing design and operations: An introduction, Edition Lavoisier 2008

8- ***RP King:*** Modeling and simulation of mineral processing systems, Edition Butterworth- Heinemann 2001

9- ***BA Wills :*** Will's mineral processing technology: An introduction to the practical aspects of ore treatment and mineral recovery Edition Butterworth-Heinemann 2006

10- Barin I., Knacke O., and Kubachewsky,O.,Thermochemical Properties of Inorganic Substances, Edition Springer Verlag, Berlin, (1977).

.

Semester: 2

Teaching Unit: UEF 2.2

Subject : Phase Diagrams

VHS: 45h00 (Lecture: 1h30; Tutorial: 1h30)

Credits: 4

Coefficient: 2

Teaching objectives:

Discover solid-solid transformations and the effects of heat treatments on alloys.

Recommended prior knowledge:

General Chemistry; Basic concepts of thermodynamics, enthalpies and entropies

Course Content: Introduction

Chapter I. **(4 Weeks)**

Thermodynamic Principles • Functions • Solutions

• Compounds •

Calorimetric

Measurements

Chapter II. Graphical Representation of Experimental Results (3 Weeks)

Chapter III. Principles of Enthalpy Diagram Construction (4 Weeks) • Binary Systems • Ternary Systems • Applications

(4 Weeks)

Chapter IV. Techniques for studying phase diagrams

• Dilatometry

• Calorimetry •

Thermal analysis

Evaluation method:

40% Continuous assessment and 60% Examination

References

-J. Bénard, A. Michel, J. Philibert, J. Talbot : General Metallurgy, Masson ed., Paris, 1984, 2nd ed., 651p.

-J.-P. Baïlon, J.-M. Dorlot : Materials, Presses Internationales Polytechniques, Montreal, 2000, 3rd ed., 736p.

-MF Ashby, DRH Jones : Materials, 2. Microstructure and implementation, Dunod ed., 1991, 385p.

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http://fr.wikiversity.org/wiki/Introduction_%C3%A0_la_science_des_mat%C3%A9riaux/Diagrammes_binaires.

Semester 2

Teaching Unit: UEF 2.2

Subject : Industrial Furnace Technology

VHS: 45h00 (Lectures: 1h30, Tutorials: 1h30)

Credits: 4

Coefficient: 2

Teaching objectives:

This subject will allow students to address the phenomena of combustion and heat transfer in industrial furnaces which are at the origin of methods of manufacturing, shaping and obtaining different types of materials.

Furnaces are the key component in the materials industry. Therefore, students must understand combustion and its chemical reactions, combustion calculations, fuels, calorific value, actual combustion temperature, and furnace classification based on flue gas circulation. Ultimately, students should be able to perform an energy balance for a furnace to minimize heat loss.

The objective of the course is to provide the student with a clear understanding of combustion, the different furnaces used in the materials industry, and their physicochemical characteristics in order to describe their applications.

Recommended prior knowledge:

Heat transfer, organic chemistry, applied thermodynamics, material classification and structure

Contents of the material:

Chapter 1. Combustion in industrial furnaces **(3 Weeks)**

1. Concepts of combustion
2. Fuels: solids, liquids, gases 3. Combustion reactions
4. Burnt gases
5. Enthalpy of formation
6. Flame temperature
7. Calorific value
8. Absolute Entropy
9. The Oswald Diagram
10. Combustion Processes

Chapter 2. Classification of Furnaces **(3 Weeks)**

1.Continuous Furnaces

2. Batch furnaces

3. Direct heating 4. Indirect heating

5. High-temperature ovens 6. Low-temperature ovens

Chapter 3. Heat Transfer in Furnaces **(3 Weeks)**

1. High-temperature furnaces
2. Low- temperature furnaces
3. Role of conduction
4. Parallel-current and counter-current heating 5. Batch furnaces

Chapter 4. Thermal Calculation of Ovens **(3 Weeks)**

1. Energy Balance
2. Allowable HeatFlux
3. Heating Quality
4. Installed Power
5. Oven Sizing

Chapter 5. Furnace Insulation **(3 Weeks)**

1. General Design
2. Definitions
3. Physics of refractory materials
4. Chemistry of refractory materials
5. Interactions between refractories and the furnace
6. Dimensioning of refractory walls

Assessment method: Continuous assessment: 40%; Examination: 60%.

References:

1. **Introduction to heat transfer, Course and solved exercises** J.-L. Battaglia, A. Kusiak, J.-R. Puiggali, 2nd Eds. DUNOD, 2014.
2. **Energy, air pollution and sustainable development,** C. Ronneau, Presses universitaires de Louvain, 2004
3. **Engineering Techniques, Industrial Furnaces** I. JACUBOWIEZ, 1998

Semester 2
Teaching Unit: UEM 2.1
Subject: Aging and degradation of materials
VHS: 45h00 (Lecture: 1h30; Practical work: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives:

This course aims to raise students' awareness of the aging problems of plastic and solid materials, the study of which is a key aspect of their development. It will enable the study of the phenomena and reactions that occur at various interfaces within the material. External chemical attacks, corrosion, and the resistance of materials to chemical substances are all covered.

Recommended prior knowledge: The knowledge required to follow this subject is summarized in general chemistry, physical chemistry, analytical chemistry and materials physics.

Contents of the material:

Chapter I: Corrosion Phenomena (5 Weeks)

- Wet corrosion: Electrochemical phenomena at the metal-solution interface, corrosion kinetics, polarization curves, passivity and passivatable metals.
- Dry corrosion: Thermodynamic approach: Ellingham diagrams.
- Kinetic approach: kinetics of oxide layer formation, study methods and mechanisms of oxidation and protection.
- Atomic diffusion phenomena in metals.
- Corrosion in industrial practice.
- Economic and phenomenological approach.
- Real-life case studies.

Chapter II: Aging and Degradation of Materials - Natural **(5 Weeks)**

Aging: solar radiation, temperature, oxygen and ozone, humidity and rain, snow, hail and sand, wind, other factors.

- Physical aging and degradation: photochemical aging, thermal aging, hydrolytic aging.

- Chemical aging: Definitions, Photo-oxidation reactions, aging without mass transfer, aging by solvent absorption, aging by migration of additives, stress cracking in a surfactant medium.

- Characterization techniques: non-destructive techniques, destructive techniques.

Chapter III: Protection of materials against corrosion - **(5 Weeks)**

Electrochemical protection (anodic protection and applications, cathodic protection, applications and calculations, protection by inhibitors and applications).

- Methods of protection against dry corrosion, by coating, by metal deposition, by vaporization of inhibitor compounds, methods of studying surface coatings, determination of criteria for choosing a protection method.

Assessment method: Continuous assessment: 40%; Examination: 60%.

References

- **French Anti-Corrosion Center :** The Stress-Fatigue- Corrosion Commission of the French Anti- Corrosion Center "Hydrogen-Material Interactions and Corrosion- Deformation", Proceedings of the Young Researchers' Days 2010, Edition "Presses De L'Ecole Des Mines", 2010.

- **Dieter Landolt,** " Treatise on Materials, Vol. 12; Corrosion and Surface Chemistry of Metals ", Edition "Presses Polytechniques Romandes", 1993

- **Collective work, "Corrosion and protection of materials at high temperature ",** Edition "Presses De L'Ecole Des Mines", 2011.

- **Marc Neveux,** " Corrosion of Water and Gas Pipes ", Eyrolles Publishing, 1968

- **François Hospital,** " Corrosion and degradation of metallic materials, understanding of the phenomena and applications in petroleum and process industries", Edition "Technip", 2010.

Semester 2

Teaching unit: UEM2.1.
Subject : Surfaces and interfaces.

VHS: 37h30 (Lecture: 1h30; Practical work: 1h00)
Credits: 3
Coefficient: 2

Teaching objectives:

Understanding the mechanisms involved at the surface and interfaces of materials interacting with a gas or a solid

Recommended prior knowledge: - Basic knowledge of general mathematics - Basic knowledge of physical chemistry and chemical engineering (thermodynamics, surface chemistry, chemical kinetics, transfer laws, etc.)

-Basic concepts of inorganic chemistry

Contents of the material:

Chapter 1:

- General introduction
- Notion of surface and interface, eigensurface.
- Scope of application of surfaces and interfaces

Chapter II: Gas Adsorption

- Introduction **(3 Weeks)**
- Forces acting between a gas molecule and the surface of a solid
- Type of adsorption
- Heat of adsorption
- Experimental techniques for determining adsorption isotherms
- Thermodynamic study of adsorption

Chapter III: Type I Adsorption Isotherm • Introduction **(3 Weeks)**

- Adsorption isotherm in localized monolayers
- Freundlich equation
- Langmuir equation

Chapter IV: Adsorption Isotherm in Multilayers **(3 Weeks)**

- BET Model

Chapter V: Surface Characterization Techniques **(6 Weeks)**

- Spectroscopic methods
  - Auger Spectroscopy
  - X-ray photoelectron spectroscopy (XPS)
- Microscopic Methods:
  - Near-field microscopy (AFM, STM)
  - Scanning electron microscopy
  - Transmission microscopy

• Porosimetric methods
- Mercury prosimmetry
- Thermoporosimetry
- Nitrogen physisorption

Assessment method:

Continuous assessment: 40%; Examination: 60%.

References: 1.

Pannetier-Souchay, Chemical Kinetics, Masson Publishing, 1964.

2. **JE Germain,** Heterogeneous Catalysis Ed. Dunod 1959.

3. **JJ Fripiat,** Physical chemistry of surface phenomena, Ed. Masson 1971.

Semester 2

Teaching Unit: UEM2.1
Subject : Practical Work - Materials Processing

VHS: 10:30 PM (TP: 1:30 AM)
Credits: 2
Coefficient: 1

Teaching objectives:

Putting into practice the basic methods of shaping materials

Recommended prior knowledge: - Basic knowledge of

general mathematics - Basic knowledge of

physical chemistry and chemical engineering (thermodynamics, surface chemistry, chemical kinetics, transfer laws, etc.)

-Basic knowledge of inorganic and organic chemistry

Course content: Your choice

TP1: Preparation of elemental silicon
TP2: Sampling, dosage and homogenization of powders
TP3: Batch grinding of cement clinker
TP4: Kinetic approach to the size reduction of solid particles
TP5: Kinetics of limestone decomposition in homogeneous and heterogeneous media
TP6: Glassmaking and Vitrification
TP7: Macromolecular Synthesis
TP8: Development of a composite material
TP9: Synthesis of a zeolite
TP10: Emulsion Polymerization

Evaluation method:

Continuous Monitoring 100%

References:

1- **Michel Fontanille Yves Gnanou,** Chemistry and physical chemistry of polymers, Dunod 3rd edition, 2013.

2- **Thibaut Starzyk, Frederic,** micro and mesoporous materials, Ed. Dunod 2004.

Semester: S2

Teaching Unit: 1.2.1

Subject: Elements of Applied Artificial Intelligence

VHS: 45h00 (Lecture 1h30, Practical 1h30)

Credits: 2
Coefficient: 2

Skills targeted: - Identify
the opportunities of artificial intelligence in engineering sciences - Understand the ethical implications of AI and the best practices for its use.
- Ability to use AI techniques in problem-solving

Objectives:
- Mastery of AI algorithms
-Introduction to the fundamental concepts, tools and applications of modern artificial intelligence, with an emphasis on practice with Python and its libraries.

- Deepen your knowledge of the Pythonlanguage,
- Understand AI approaches to problem-solving.
- **Prerequisites:** Advanced Python programming.
- **Required materials:** - A computer with Python installed,
- Python libraries: NumPy, Pandas, Scikit-learn, Matplotlib, os.listdir, os.path.exists.
os.mkdir, os.rmdir, Matplotlib, Seaborn, Plitly, Request, Beautiful Soup, Tkinter, PyQT, …
- Tensorflow, PyTorch, …

Content of the material:

Chapter 1: Introduction to Artificial Intelligence (AI) 1. Definitions and fields of application of AI. **(1 week)**

2. Historical evolution of AI.

3. Introduction to the main areas:
- Automatic learning (Machine Learning)
- Deep learning

Chapter 2: Basic Mathematics for AI 1. Linear Algebra : (1 week)
Vectors, Matrices, Products, Norms.

2. Probability & Statistics :
- Variables, expectation, variance.
- Common distributions: normal, binomial, uniform.

3. Simple linear regression :
- Formulation, cost, optimization.
- Implementation with **Scikit-learn.**

4. Exercises:
- Matrix manipulation using the NumPy library (Python) • Exercise on linear regression (using a Python library such as Scikit-learn) • Explaining the Matplotlib library (Python)

Chapter 3: Machine Learning (3 weeks)

1. Key concepts: Data, Models, features, labels, generalization.
2. Phases of a learning pipeline: training, validation, testing.
3. Types of learning:

- Supervised
- Unsupervised
- By reinforcement *(overview)*

4. Exercises:

- To delve deeper into the concepts covered in the course
- …

Chapter 4: Supervised Classification 1. **(3 weeks)**

Principle of training a simple classification model: **2.** Models and algorithms: • SVM (Support Vector Machine) • Decision trees **3.** Performance evaluation:

- Confusion matrix, precision, recall, F1-score.

5. Exercises:

- Explain how to use Scikit-learn? • Compare several models on a dataset
- …

Chapter 5: Unsupervised Learning 1.

Concept of clustering.

2. Algorithms:

- **K-means**
- DBSCAN (Density-Based Spatial Clustering of Applications with Noise)

3. 2D visualization and interpretation of results.

4. Exercises:

- Explain how to use a clustering algorithm on a Dataset • Explain how to visualize the clusters.
- …

Chapter 6: Neural Networks

1. Architecture of a neural network:

- Perception,
- Layers and hidden layers, weight, bias.
- Activation function: ReLU, Sigmoid, Softmax, ….
- Application Exercises **2.**

Introduction to **Deep Learning :**

- Concept of deep layers.
- Introduction to convolutional neural networks (CNNs)

3. Exercises:

- Explain TensorFlow and PyTorch • Analyze a text dataset and predict sentiment
- …

Chapter 7: Mini project (supervised personal work outside of class):

Creation of a complete classification or clustering model, including preprocessing, training, and visualization; choosing and completing one project from start to finish (to be distributed at the beginning of the semester): o Handwriting recognition

- o Natural disaster prediction o Developing a chatbot capable of answering frequently asked questions from a company. in a natural way.
- o Develop a system capable of distinguishing normal machine sounds from those indicating an anomaly (defective bearing, excessive vibration, etc.)

- Develop a system (mini AI) capable of analyzing the sentiments expressed in social media posts about a product, brand or event.
- …

Practical exercises:

Lab 01: Initialization

TP 02 : •

Implement a simple regression with Scikit-learn and visualize with Matplotlib (for example)

- Visualize the results with Matplotlib
- …

Lab 03:

- Machine learning pipeline and data separation
- To delve deeper into the concepts covered in the course

Lab 4:

Using Scikit-learn to train a simple classification model

- …….

TP 05: •

Implement a clustering algorithm on a Dataset • Visualize the clusters:

Unsupervised clustering (K-means, DBSCAN).

- …

Lab 06:

• Build a simple neural network with TensorFlow, PyTorch, or Keras • Build a simple CNN to classify images (example: MINIST dataset)

- …

Evaluation method:

exam 60% , CC=40%

Bibliography: -

Ganascia, J. Gabriel (2024): AI explained to humans. Paris, France - Edition le Seuil.

- Anglais, Lise, Dilhac, Antione, Dratwa, Jim et al. (2023): Ethics at the heart of AI. Quebec Obvia.

- J. Robert (2024): Natural Language Processing (NLP): Definition and Principles – Data Science. Link: https://datascientest.com/introduction-au-nlp-natural-language-processing - What is natural language processing? Link: https://aws.amazon.com/fr/what-is/nlp/ - M. Journe: Elements of Discrete Mathematics – Ellipses - F. Challet: Deep Learning with Python – Eyrolles - H. Bersini (2024): Artificial Intelligence in Practice with Python – Eyrolles - B. Prieur (2024): Natural Language Processing with Python – Eyrolles - V. Mathivet (2024): Implementation in Python with Scikit-learn – Eyrolles - G. Dubertret (2023): Introduction to Cryptography with Python – Eyrolles - S. Chazallet (2023): Python 3 – The Fundamentals of the Language – Eyrolles - H. Belhadef, I. Djemal: NLP Method – University of Msila Course – Algeria

Semester 2

Teaching Unit: UET 1.2
Subject: Compliance with ethical standards and rules of integrity

VHS: 10:30 PM (Class: 1 hour 30 minutes)
Credit: 1
Coefficient: 1

Teaching objectives:

To raise students' awareness of ethical principles and the rules governing life at university and in the workplace. To educate them about respecting and valuing intellectual property. To explain the risks of moral failings such as corruption and how to combat them, and to alert them to the ethical issues raised by new technologies and sustainable development.

Recommended prior knowledge:

Ethics and professional conduct (the foundations)

Content of the material:

A. Respect for ethical and integrity rules,

1. **Reminder of the MESRS Charter of Ethics and Professional Conduct:** Integrity and honesty. Academic freedom. Mutual respect. Demand for scientific truth, objectivity and critical thinking. Equity. Rights and obligations of students, teachers, administrative and technical staff,

2. **Ethical and responsible research**

- Respect for ethical principles in teaching and research
- Responsibilities in teamwork: Equal professional treatment. Conduct against discrimination. Pursuit of the common good.

  Inappropriate conduct in the context of teamwork

- Adopting responsible conduct and combating abuses: Adopting responsible conduct in research. Scientific fraud. Conduct against fraud. Plagiarism (definition of plagiarism, different forms of plagiarism, procedures to avoid unintentional plagiarism, detection of plagiarism, sanctions against plagiarists, etc.). Falsification and fabrication of data.

3. **Ethics and professional conduct in the workplace:**

Legal confidentiality in business. Loyalty to the company. Responsibility within the company. Conflicts of interest. Integrity (corruption in the workplace, its forms, its consequences, methods of combating and sanctions against corruption).

B- Intellectual Property

I- Fundamentals of intellectual property 1-

Industrial property. Literary and artistic property.

2- Rules for citing references (books, scientific articles, conference papers, theses, dissertations, etc.)

II- Copyright

1. Copyright in the digital environment

Introduction. Copyright of databases, copyright of software. Specific case of free software.

2. Copyright on the Internet and E-commerce: Domain name law.

Intellectual property on the internet. E-commerce website law. Intellectual property and social networks.

3. Patent

Definition. Rights in a patent. Usefulness of a patent. Patentability. Patent application in Algeria and worldwide.

III- Protection and enhancement of intellectual property

How to protect intellectual property. Violation of rights and legal tools.
Valuation of intellectual property. Protection of intellectual property in Algeria.

C. Ethics, sustainable development and new technologies

Link between ethics and sustainable development, energy efficiency, bioethics and new technologies (artificial intelligence, scientific progress, humanoids, robots, drones,

Evaluation method:

Exam: 100%

References:

1. Charter of University Ethics and Professional Conduct, https:// www.mesrs.dz/documents/12221/26200/Charte+fran__ais+d__f.pdf/50d6de61-aabd-4829-84b3-8302b790bdce
2. Decree No. 933 of July 28, 2016 establishing the rules relating to the prevention and control of plagiarism
3. The ABCs of Copyright, United Nations Educational, Scientific and Cultural Organization culture (UNESCO)
4. E. Prairat, On teaching ethics. Paris, PUF, 2009.
5. Racine L., Legault GA, Bégin, L., Ethics and Engineering, Montreal, McGraw Hill, 1991.
6. Siroux, D., Deontology: Dictionary of Ethics and Moral Philosophy, Paris, Quadrige, 2004, pp. 474-477.
7. Medina Y., Ethics, what will change in the company, Organisation editions, 2003.
8. Didier Ch., Thinking about the ethics of engineers, Presses Universitaires de France, 2008.
9. Gavarini L. and Ottavi D., Editorial. of professional ethics in training and research, Research and training, 52 | 2006, 5-11.
10. Caré C., Morality, ethics, deontology. Administration and education, 2nd quarter 2002, no. 94.
11. Jacquet-Francillon, François. Concept: professional ethics. Le télémaque, May 2000, no. 17
12. Carr, D. Professionalism and Ethics in Teaching. New York, NY Routledge. 2000.
13. Galloux, JC, Industrial Property Law. Dalloz 2003.
14. Wagret F. and JM., Patents, trademarks and industrial property. PUF 2001
15. Dekermadec, Y., Innovating through patents: a revolution with the internet. Insep 1999
16. AEUTBM. The engineer at the heart of innovation. University of Technology of Belfort-Montbéliard
17. Fanny Rinck and Léda Mansour, Literacy in the digital age: copy-pasting among students, Grenoble 3 University and Paris-Ouest Nanterre La Défense University, Nanterre, France

18. Similarity detection software: a solution to electronic plagiarism? Report of the Working Group on Electronic Plagiarism presented to the Subcommittee on Pedagogy and ICT of the CREPUQ
19.
20. Emanuela Chiriac, Monique Filiatrault and André Régimbald, Student Guide: Intellectual Integrity, Plagiarism, Cheating and Fraud… Avoiding Them and, Above All, How to Properly Cite Your Sources, 2014.
21. University of Montreal publication, Strategies for preventing plagiarism, Integrity, fraud and
22. plagiarism, 2010.
23. Pierrick Malissard, Intellectual Property: Origin and Evolution, 2010.
24. The website of the World Intellectual Property Organization www.wipo.int
25. http://www.app.asso.fr/

IV - Detailed program by subject for Semester S3

Semester: 3
Teaching unit: UEF3.1.1
Subject: Porous and dispersed media
VHS: 45 hours (Lectures: 1 hour 30 minutes; Tutorials: 1 hour 30 minutes)
Credit: 4
Coefficient: 2

Learning objectives (Describe what skills the student is expected to have acquired after successful completion of this subject – maximum 3 lines).

The objective is to master the industrial-scale production processes of certain polymers by studying their properties and areas of use.

Recommended prior knowledge (brief description of the knowledge required to follow this course – Maximum 2 lines).

The knowledge required to follow this module includes organic chemistry, inorganic chemistry, general chemistry, and rheology.

Content of the material:

Chapter 1. Particle Size **2 Weeks**

Analysis : Morphology of a grain, particle size analysis and use of particle size analysis.

Chapter 2. Crushing and Fragmentation **3 Weeks**

Crushing, screening and sieving operations. Energy laws of fragmentation.

Chapter 3. Fluid Flow Through a Porous Medium . Flow of a **3 Weeks**

single fluid through a porous medium. Kozeny model, tortuous pore bundle model. Ergun equation. Calculation of the pressure drop in packed columns.

Constant flow filtration , Constant pressure filtration, cake filtration application.

Chapter 4. Movement of grains in fluids Flow of a **3 Weeks**

single fluid around a grain, vertical movements of grains in a gravitational field, calculation of terminal free-fall velocity, two-dimensional motion.

Chapter 5. Sedimentation **2 Weeks**

Gravity settling: sizing a settling tank
Decantation by centrifugation: sizing of a gas cyclone.

Chapter 6. Fluidization. **2 Weeks**

Homogeneous fluidization: Experimental study of pressure loss and bed porosity, minimum fluidization threshold. Theoretical study of bed expansion and heterogeneous fluidization.

Assessment method: Continuous assessment: 40%; Examination: 60%.

References:

1. DULLEN(FAL)-Porous media: fluid transport and port structure (medieux poreux: transport des fluides et structure poreuse) 1979 Academic Press.New York.
2. Rhodes, M., Introduction to ParticleTechnology, 2nd Ed., Wiley (2008).
3. Refining and Chemical Engineering Volume II. P. Wuithier. Editions Technip. Paris 1965.
4. Gibilaro, LG, Fluidization - Dynamics, Butterworth - Heinemann (2001).

5. Perry RH, DW Green And JO Maloney, "Perry's Chemical Engineers' Handbook" seventh edition, , McGraw Hill, 1999

6. Coulson JM, JF Richardson, JR Backhurst And JH Harker, "Chemical Engineering", volume two, Fifth edition, Pergamon Press, 2002.

McCabe WL, JC Smith and P. Harriott, "Unit Operations of Chemical Engineering", seventh edition, ed.McGraw-Hill,2004.

Semester: 3

Teaching unit: UEF3.1.2
Subject: Polymer and Composite Materials
VHS: 67H30 (Lectures: 3h00; Tutorials: 1h30)
Credit: 6
Coefficient: 3

Learning objectives (Describe what skills the student is expected to have acquired after successful completion of this subject – maximum 3 lines).

The objective is to master the industrial-scale manufacturing processes of certain polymers by studying their properties and applications. The focus will be on matrix composites, whether polymer, metallic, or ceramic, with fibrous or particulate reinforcements. Adjuvants and additives are mixed with these materials to obtain products with properties suited to various uses. The aim is to understand the mechanisms of action of the stabilizers and additives used in the processing of these materials.

Recommended prior knowledge (brief description of the knowledge required to follow this course – Maximum 2 lines).

The knowledge required to follow this module includes organic chemistry, inorganic chemistry, general chemistry, and rheology.

Content of the material:

Chapter I: Definitions of Industrial Polymers **2 Weeks**

- Fundamental definitions of polymers
- Definitions of industrial polymers

Chapter II: Industrial Polymer Development **2 Weeks**

- Materials used
- Manufacturing processes

Chapter III: Properties of Industrial Polymers **2 Weeks**

- Chemical and electrochemical properties
- Physical properties
- Mechanical properties
- Other properties and areas of employment

Chapter IV: General Information on Composite Materials **3 Weeks**

Definition and classification of composites

- Volume fractions, mass fractions

- Constituent elements of composite materials (resins, fillers and additives, fibers and fabrics, main fibers)

Chapter V: Additives in composite materials **3 Weeks**

- Role of additives

Different types of additives: colorant pigments, UV stabilizers, IR stabilizers, thermal stabilizers, compatibilizers, antistatic agents, flame retardants

- Loads and reinforcements

Chapter VI: Methods for implementing composite materials **3 Weeks**

- Formulations adapted to meet the transformation processes and desired properties

- Transformation of composites
- Implementation processes and structure of composite materials
- Strengthening of thermosetting resins
- Use of semi-finished products, SMC and BMC composite architecture, lamination, pultrusion, RTM and RIM, spray molding
- Surface treatment, cutting and assembly of composites
- Reinforcement of thermoplastic resins: Injection, manufacturing and

molding of plates in TRE, Other processes

- Reinforcement of rigid or semi-rigid foams : Molding between a mold and a counter-mold, spray molding

Assessment method: Continuous assessment: 40%; Examination: 60%.

References *(Books and handouts, websites, etc.).*

1. Marc Carrega, Industrial Materials - Polymer Materials, Dunod Edition, June 2000.

2. Jean-Pierre Cohen, Polymer: Plastic Material, Belin Publishing, 2007

2009. Plastics - Reference guide, 2nd edition Dunod, 7 3. Marc Carrega, October

4. Jean Pierre Mercier, Polymer Chemistry, Syntheses, Reactions, Degradations, 1st edition, 1993.

Semester: 3

Teaching unit: UEF3.2.1 Course
subject: Lens Technology

VHS: 45 hours **(Lectures: 1 hour 30 minutes; Tutorials: 1 hour 30 minutes)**
Credit: 4
Coefficient: 2

Learning objectives *(Describe what skills the student is expected to have acquired after successful completion of this subject – maximum 3 lines).*
The objective is to study the vitreous state and properties of industrial glasses, as well as the processes of production and shaping.

Recommended prior knowledge *(brief description of the knowledge required to follow this course – Maximum 2 lines).*
To follow this subject well, the student must have knowledge of silicate chemistry, phase diagrams, thermodynamics and crystallography.

Content of the material: Lens technology

Chapter I - Study of the vitreous state according to different theories **3 Weeks**

Chapter II - Study of the properties of industrial glasses **3 Weeks**

II-1: Optical Properties
II-2: Mechanical Properties II-
3: Thermal Properties
II-4: Electrical Properties II-
5: Phonic Properties
II-6: Chemical Properties

Chapter III- **3 Weeks**

Studies of raw materials for the manufacture of industrial glass

III-1: Properties of raw materials III-
2: Raw Materials Processing
III-3: Preparation of starting mixtures

Chapter IV - Preparation of vitreous molten glass and melting of glass **3 Weeks**

IV-1: Dehydration of the mixture IV-
2: Solid-phase reaction
IV-3: Melting of the vitreous mixture
IV-4: Refining and homogenizing the vitreous mixture

Chapter V: Shaping Processes and Types of Glass **3 Weeks**

I- Shaping of flat glasses
II-Shaping of hollow glasses
III- Shaping of optical lenses
IV- Fiberglass

Assessment method: Continuous assessment: 40%; Examination: 60%.

References *(Books and handouts, websites, etc.).*

1. Collective, " Mechanical Glass Manufacturing Industries ", Edition "Documentation Française", 2006.
2. J. Travail, "Handmade, semi-automatic and mixed glassmaking ", Edition "Interactive Resource Center", 2010.
3. J. Travail, Glass (mechanical manufacturing), Edition "Interactive Resource Center", 2010.
4. Collective work, " Glassmaking and Working ", "Lebègue and Schepens" edition, 1907.

Semester: 3
Teaching Unit: UEF3.2.2
Subject: Ceramics Technology and Binders
VHS: 45H00 (Lecture: 1h30; Tutorial: 1h30)
Credit: 4
Coefficient: 2

Learning objectives (Describe what skills the student is expected to have acquired after successful completion of this subject – maximum 3 lines).
The objective is to study the manufacturing processes of ceramic materials and binders, the different types of ceramic materials and binders, their properties and areas of use.

Recommended prior knowledge (brief description of the knowledge required to follow this course – Maximum 2 lines).
To follow this subject well, the student must have knowledge of silicate chemistry, mineral chemistry, phase diagrams, thermodynamics, crystallography and rheology.

Subject matter: Ceramic technology and binders

Chapter I - Preparation of ceramic masses **2 Weeks**
I-1: Effect of grinding on the properties of ceramic materials I-2: The colloidal nature of plastic masses
I-3: Study of the rheology of ceramic masses I-4: Study of pH in ceramics

Chapter II - Drying Process of Ceramic Products **2 Weeks**
II-1: Water-clay system
II-2: Study of shrinkage during drying
II-3: Parameter influencing withdrawal
II-4: Drying Curve
II-5: Drying Process

Chapter III - Firing Process of Ceramic Products **2 Weeks**
III-1: Formation of the ceramic shard III-2: Enameling of ceramic products
III-3: Cooking curve and control of the cooking process **Chapter IV - Portland Cement Manufacturing Process** IV-1: Preparation of the raw mixture **2 Weeks**
IV-2: Dehydration of the raw material
IV-3: Decomposition of carbonates IV-4: Reactions in solid phases
IV-5: Solid-Liquid Reaction
IV-6: Clinker Cooling

Chapter V - Properties of Portland Cement **2 Weeks**
V-1: Chemical Properties
V-2: Mineralogical Properties
V-3: Structural and morphological properties

V-4: Physical and mechanical properties V-5:

Using Add-ons

Chapter VI - Manufacture and properties of other hydraulic binders **2 Weeks**

VI-1: Lime Production

VI-2: Plaster Casting Production

VI-3: Special Cements

VI- 4: Standardization relating to cements

Chapter VII - Contribution to environmental protection **1 Week**

VII- 1: Use of industrial waste in cement manufacturing

VII-2: Minimizing emissions of polluting gases (CO2, SOx, NOx, …)

Assessment method: Continuous assessment: 40%; Examination: 60%.

References *(Books and handouts, websites, etc.).*

1. CA JOUENNE, “Treatise on Ceramics and Mineral Materials”, Edition “SEPTIMA”, 1984.
2. Lurcat Jean, “Ceramics”, Edition “Académie des Beaux-Arts”, 2004.
3. Taylor Louisa, " The Big Book of Ceramics: Tools and Techniques" of today ”, Edition “Pyramyd”, 2011.
4. Pescheteau-Badin-Ferrien, “ French Porcelain, Earthenware, Books on the "Ceramics", Edition "AT THE AUTHOR'S", 1991.
5. Collective, “Cement manufacturing industry”, Edition “Document. French”, 2006.
6. J. Boero, " Manufacture and Use of Hydraulic Limes and Cements ", Edition “BERANGER” 1925.
7. Collective, “Cement manufacturing industry”, Edition “Document. French”, 2003.
8. J. Fritsch, " Cement Manufacturing ", Scientific Self-Edition and "Industrial", 1911.
9. L. Blondiau “ Supersulfated metallurgical cement, Manufacturing principles, "Physical, chemical and mechanical properties", Edition "Revue des matériaux de construction et de travaux publics", 1939.
10. Collective, “ Cement manufacturing industry ”, Edition “Documentation Française”, 2003.

Semester: 3

Teaching Unit: UEM 2.1

Subject : Application of materials in water pollution control

VHS: 10:30 PM (TP: 1:30 AM)

Credit: 2

Coefficient: 1

Teaching objectives :

Training of field specialists with solid theoretical and practical knowledge of airborne pollution problems. Graduates will be able to manage air quality control and monitoring issues and develop the necessary instrumentation and techniques.

Recommended prior knowledge: Chemistry, physical chemistry, thermodynamics, chemical equilibria, chemical reaction kinetics, physical chemistry of pollutants.

Course content: (Practical work of your choice)

TP N 1: Manufacturing processes of porous and divided materials (Activated carbons, Zeolites, Modified clays, Molecular sieves (aluminophosphates) ….

TP N 2: *Batch* adsorption of organic pollutants (humic acids or phenols or…,…) on an adsorbent (synthetic zeolite, activated carbon, modified clay,….)

TP N 3: *Dynamic* adsorption of organic pollutants (humic acids or phenols or…,…) on an adsorbent (synthetic zeolite, activated carbon, modified clay,….) in fixed bed mode.

Lab 4: *Batch* Adsorption of a Heavy Metal (Ni, Co, Cu, Zn…) on a adsorbent (synthetic zeolite, activated carbon, modified clay, etc.)

Lab 5: *Dynamic* adsorption of a heavy metal (Ni, Co, Cu, Zn…) on an adsorbent (synthetic zeolite, activated carbon, modified clay,….) on a fixed bed

TP N 6: Development of ion exchangers: Synthetic exchangers (polymers) and natural exchangers (zeolites).

Lab 7: Application of ion exchangers in deionization

Practical Exercise No. 8: Application of ion exchangers in water softening and purification

Practical Exercise No. 9: Elimination of water pollution by coagulation and flocculation using clays, activated silicas, etc.).

TP N 10: Elimination of water pollution by electrocoagulation.

Practical Exercise No. 11: Degradation of organic pollutants (pesticides, dyes, etc.) using adsorbent and/or catalytic materials (zeolites, anionic clays, bridged clays, titanium oxides, etc.)

Assessment method: Continuous assessment: 100%

References *(Books and handouts, websites, etc.).*

1. G. BURGOT, JL BURGOT Instrumental methods of chemical analysis and applications: Chromatographic methods, electrophoresis and spectral methods,
2. A. BAILLY, M. CLERC-RENAUD, E. RUTMAN, C. TERNANT Engineering Techniques Volume BE5 (ref BE9271): air treatment and air conditioning,
3. R. EECKELAERS Ion exchangers and their use in industry, 4. J. REGALBUTO.

Catalyst preparation: Science and engineering. CRC Press. Taylor & Francis Group. 2007. UK

5. JIMMY L. HUMPHREY ، GEORGE E. KELLER, Techniques, Selection, Dimensioning (Technical Industries), Dunod Edition
6. KOLLER (Emilian), "Treatment of industrial pollution: Water, air, waste, soil, sludge", ed Dunod 2004.
7. *BLAISE* JEAN-FRANCOIS, Decolorization of yeast wastewater by adsorption on carbon, Journal *of Environmental Engineering and Science*, 2004, 3(4): 269-277.
8. GANGNEUX and D. WATTIEZ, Syntheses and studies of ion-exchange celluloses. Their use in the treatment of wastewater from the textile industry-III, European Polymer Journal, Vol. 12, pp. 551 to 557. Pergamon Press 1976.
9. G. BURGOT, JL BURGOT Instrumental methods of chemical analysis and applications: Chromatographic methods, electrophoresis and spectral methods,
10. A. BAILLY, M. CLERC-RENAUD, E. RUTMAN, C. TERNANT Engineering Techniques Volume BE5 (ref BE9271): air treatment and air conditioning,
11. R. EECKELAERS, Ion exchangers and their use in industry,

Semester: 3

Teaching Unit: UEM 2.1

Subject : Process Modeling and Optimization

VHS: 37h30 (Lectures: 1h30; Practical work: 1h00)

Credit: 3

Coefficient: 2

Teaching objectives :

To provide the student with the research methods necessary for methodology and experimental research and process optimization

Recommended prior knowledge: Basic

understanding of analysis and algebra; Basic understanding of physical chemistry and chemical engineering (thermodynamics, surface chemistry, chemical kinetics, transfer laws, etc.); Basic understanding of inorganic and organic chemistry

Content of the material:

Introduction	**1 Week**
Chapter I : Methodology of Scientific Research	**2 Weeks**
Chapter II: Analysis of Some Strategies **Chapter**	**2 Weeks**
III: Hadamard's Matrix	**2 Weeks**
Chapter IV: Quantitative Study of Factors **Chapter**	**2 Weeks**
V: Quantitative Study of Responses **Chapter VI:**	**2 Weeks**
Optimization and the Simplex Method	**2 Weeks**

Lab 1: Numerical modeling of the structure of a composite material
2 Weeks

Assessment method: Continuous assessment: 40%; Examination: 60%.

References *(Books and handouts, websites, etc.).*

1. Optimization of chemical processes. TF EDGAR, DM HIMMELBLAU. McGraw-Hill. 1989.
2. Books: K. Najim; G. Muratet, Optimization and control in process engineering.
3. Simulation and optimization in process engineering: GFGP Recent progress in process engineering processes, Vol 2 No. 6. Tech & Doc Lavoisier 1988.
4. **Poux, Martine,** Sustainable Process Engineering: From Concept to... industrial implementation, Ed. Dunod 2010.

Semester: 3

Teaching Unit: UEM 2.1
subject: Application of catalytic materials to chemical reactions

VHS: 10:30 PM (Class: 1 hour 30 minutes)
Credit: 2
Coefficient: 1

Teaching objectives :
This course covers all facets of heterogeneous catalysis: preparation, characterization, shaping, use, regeneration – in other words, the entire life cycle of the catalyst.

Recommended prior knowledge: Kinetics and
catalysis, surface analysis methods, chemical engineering.

Content of the material:

Chapter I: Review of basic concepts in heterogeneous catalysis: Redox catalysis, Acid-base catalysis **1 Week**
Chapter II:
Preparation
and characterization of heterogeneous catalysts **2 Weeks** **2 Weeks**
Chapter III: Shaping of catalysts and activation. **4 Weeks**
Chapter IV: Catalyst in operation: Diffusion, reaction, deactivation… **2 Weeks**
Chapter V: Catalyst Regeneration. **4 Weeks**
Chapter VI: Industrial Processes of Heterogeneous Catalysis:

1. Petroleum Refining and Petrochemistry
2. Chemistry
3. Fine Chemistry
4. Environmental protection (exhaust gas treatment, catalytic combustion, fuel cells…)

Assessment method: 100% exam

Reference :

1. Chemical-Kinetic Engineering and Heterogeneous Catalysis, B. Gilot, R. Guiraud, Ed. Ellipses
2. Heterogeneous Catalysis, P. Selwood, Burnell, Ed. Technip
3. Reaction Kinetics in Heterogeneous Catalysis, Boudart, Ed. Masson
4. Applied heterogeneous catalysis, JF Lepage, Ed. Technip

Semester: 3
Teaching Unit: UEM2.1 Subject 4: Life Cycle Analysis of Materials and Calculation of Economic Balance VHS: 22h30 (Lecture: 1h30)
Credit: 2
Coefficient: 1

Teaching objectives: The objective is to conduct economic and environmental assessments to optimize spending and improve the environmental impact of the materials industry.

Recommended prior knowledge: The knowledge required to study this subject includes thermodynamics, heat transfer, atmospheric pollution, and solid waste pollution.

Content of the material:

Chapter I: Introduction (2 **weeks)**
- Review of thermodynamics
- Review of environmental chemistry and pollution

Chapter II: Calculating the Economic Balance of Materials Production (6 **weeks)**
I- Determining the input and output parameters
II- Establishing the numerical equations
III- Calculation of the heat balance
IV- Calculation of the overall energy balance
V- Determination of the final economic balance

~~Chapter III:~~ ~~Life~~ Cycle Assessment (LCA) of Materials (7 **weeks)**
I- Concepts of LCA
II- Determination of the environmental impacts of materials before, during and after manufacture and use
III- Establishing calculation formulas
IV- Calculation of the LCA
V- Comments on the ecology of the materials analyzed

Evaluation method:

Exam: 100%

References:

1. Léon Perlemuter and Gabriel Perlemuter CSI 2.2 - Life cycles and major functions, 2010.
2. Daisaku Ikeda, The Cycle of Life: A Buddhist Perspective, 2006.
3. Philippe Osset and Laurent Grisel, The analysis of the life cycle of a product or service: Applications and practical implementation, 2008.

Semester: 3

Teaching Unit: UET 2.1

Subject 2: Chemical reverse engineering

VHS: 67h30 (Lectures: 1h30, Tutorials and/or Practical Sessions: 1h30)
Credits: 2
Coefficient: 2

Teaching objectives:

To train the student in:

- Competitive intelligence
- Quality approach (quality control of a product with a supplier allowing traceability, conformity analysis for example)
- Understanding/anticipation of various phenomena (premature aging, product responsiveness, structure-property relationship...).
- Substitution of raw materials (shortage or strategic change)
- Product optimization
- Obtaining data for regulatory compliance
- Protection of intellectual property (verification of patent infringement, unfair competition, etc.)

Recommended prior knowledge:

Physicochemical methods of analysis (spectroscopy, microscopy, thermal analysis, etc.)

Content of the material:

Chapter 1 Introduction to Chemical Reverse Engineering

1.1 History, legal and ethical issues of RE, -

Definitions and fields of application: Approaches (hardware, software, processes…)

- Product design objectives, constraints that may have influenced the product, For which market was the product created? How does the product work?
- How do we think it works? How does it meet the overall objective of the Design? Why was it designed this way?

1.2 Methods and use

- Chromatography: separating and identifying the different components of a mixture
- Spectroscopy: identifying and quantifying the chemical bonds and elements present in a sample
- Microscopy: examining the microstructure of a sample
- Thermal analysis: studying the thermal properties of a sample
- Rheology: studying the mechanical properties of a sample as a function of time and temperature

1.3 Areas of Use

- Polymer, paint, ink, powder, ceramic, and composite industries packaging
- Pharmaceutical and drug industries
- Food industries
- Cosmetics industries
- Petrochemical industries

1.1 Cases where reverse engineering is not possible

- Complex formulations
- Lack of equipment
- Legal restrictions
- Security problems
- Degradation

Chapter 2 General Methodology

2.1 Inverted Pyramid

2.1.1 Overall product analysis: Documentary evaluation of the mixture to be reformulated,

2.1.2 Surface analysis of the mixture: solubility, chemical reactivity, presence of charge, number of compounds forming the mixture, size of molecules

2.1.3 Specific analysis of each of the compounds to be reformulated: isolate the different species then identify and characterize them using chromatography, NMR, elemental analysis techniques (SEM, EDX…)

2.1.4 Quantification of isolated species (chromatography, NMR, gravimetric techniques)

2.1.5 Examples of applications: Reverse engineering of epoxy resins, phenolic resins, paints, shampoos, medical devices, etc.

Chapter 3 Reverse Engineering Process

3.1 Hypothesis on the manufacturing process

Reconstruction of the manufacturing steps based on the chemical composition:

- Temperature, pressure, catalysts used.
- Order of adding reagents.
- Conditions of reaction and purification.

3.2 Modeling and simulation

- Use of chemical simulation software (Aspen Plus, ChemCAD, etc.) to validate the hypotheses.
- Evaluation of thermodynamic and kinetic equilibria.

3.3 Experimental Reproduction

- Conducting laboratory tests to verify formulation hypotheses or of process.
- Adjusting the parameters based on the results obtained.

3.4 Optimization

- Improvement of the process (yield, cost, environmental impact).
- Search for equivalent or better formulations (generics, patentable alternatives, etc.).

Chapter 4 Techniques for developing generic pharmaceutical forms

4.1. Research and formulation:

4.2. Bioequivalence tests:

Bioequivalence of generic drugs with the reference drug,

4.3. Toxicological, pharmacological and clinical studies:

4.4. Application for marketing authorization (MA):

4.5. Quality control:

Chapter 5 Polymer Development Techniques

5.1 Sample Acquisition and Preparation

- Acquisition: raw material or prototype

Preparation: cleaning, drying, and preparation of the sample for analysis according to the analytical technique used.

5.2. Analysis and Characterization (physical and chemical)
(microscopy, spectroscopy (e.g., FTIR, NMR), thermal analysis, and other methods for determining the structure, composition, and properties of polymers.

5.3. Formulation and Reconstruction: •

Understanding the composition:

- Reproduce the process:

5.4. Validation and optimization: •

Testing and validation:

- Optimization:
- Production: (original product, or develop a new one)

5.5. Advantages of reverse engineering in polymer development:

- Reproduction of products:
- Improvement of existing products:
- New product development:
- Cost reduction:
- Understanding of competitor products:

Chapter 6 Reverse Engineering of a Commercial Liquid Detergent

Step 1: Existing Product (Sampling) : **Collection of the liquid detergent product to be analyzed**

Step 2: Physico-chemical analysis :

- Identification of surfactants - Identification of polymers or additives.

Step 3: Identified components:

- Dosage of components

Step 4: Hypothesis on the formulation

Step 5: Reconstitution of the process

Reconstruction of the probable process:

1. Cold mixing
2. Solubilization
3. pH adjustment
4. Addition of preservatives and fragrance

Step 6: Lab Tests

Reproduce the mixture using the estimated proportions. Adjust according to viscosity, foaming, pH, and stability.

Step 7: Adjustments and testing

Evaluate performance: cleaning power, stability, cost.

Step 8: Final Formulation

Optimization : Add improvements: biodegradable agents, better fragrance, cost reduction.

Remarks :

- In the case of a formulated product (such as a detergent), the **separation and identification of components** is essential.

Certain substances, such as perfumes or preservatives, can be present at **very low concentrations,** but play a **key role** in the performance or perception of the product.

Chapter 7 Analysis of a 5W-30 Multigrade Engine Oil

Objective: *To understand the* chemical composition *and* technical properties *of a competitor's 5W-30 engine oil (e.g., Total, Mobil, Shell), in order to:*

- ***Reproduce an equivalent lubricant,***
- ***Identify the additives used,***
- ***Develop a product with comparable or improved performance.***

7.1 Characteristics of an engine oil to be analyzed

• **SAE Grade :** 5W-30 (good cold fluidity + hot weather protection) •

Specifications : API SP, ACEA C3 •

Application : modern gasoline and diesel engines, with DPF or catalytic converter

7.2 Reverse Engineering Steps

1. Sample preparation

• Fresh (new) sample taken from a sealed container. • Analysis is also possible on used oil to study performance in real-life conditions.

2. Physico-chemical analyses:

Kinematic viscosity analysis,
Viscosity index (VI)
Flash point / Freezing point Spectrometric analyses (ICP-AES, FTIR / GC-MS …)

3. Typical composition identified

Component
API Base Group III or IV
ZDDP (zinc dialkyldithiophosphate) Calcium / Magnesium
Phosphorus
Viscosity-modifying polymers
Dispersants (borates, succinimides)
Corrosion inhibitors

4. Reconstitution in Formulation **5.** Validation Tests •

Tribological tests (4-ball test, ASTM D4172) • Engine simulation (IVA, VG sequence, etc.) • Engine bench tests (durability, fuel consumption) • Compatibility with catalytic converters and particulate filters Final Result • Formulation of a 5W-30 engine oil meeting API/ ACEA standards. • Possibility of formulating a **low SAPS alternative** for modern engines. • Reduction of sulfated ash and adaptation to Euro 6/7 vehicles.

Notes :

Reverse engineering of an engine oil requires **advanced knowledge in Tribology, organic chemistry and technical standards.**

The use of **industrial additive packages** simplifies formulation. but their exact nature is often **confidential.**

• Patents and **regulatory requirements** (REACH, manufacturer standards) **must** to be respected.

Evaluation method:

- Practical work (30%) - Mini reverse engineering project (report + presentation) 40% - Final exam (multiple- choice questions + case study) 60% - Continuous assessment (40%)

Bibliographical references: •

Jacques Villermaux, *Chemical Reaction Engineering: Design and Operation of Reactors,* Tec & Doc Editions, 1993. • **Daniel Schweich,** *Chemical Reaction Engineering,* Tec & Doc Editions, 2001.

- **Gilbert F. Froment & Kenneth B. Bischoff,** *Chemical Reactor Analysis and Design,* Wiley, 2010.
- **Searson, DP, Willis, MJ, & Wright, A.,** *Reverse Engineering Chemical Reaction Networks from Time Series Data,* 2014.
- **Marote, P., Martin, M., Bonhomme, A., Lantéri, P., & Clément, Y.,** *Artificial Intelligence for Reverse Engineering: Application to Detergents Using Raman Spectroscopy,* 2023.
- **Techniques de l'Ingénieur,** *Chemical Processes: Complete Dossier.*

Semester: 3
Teaching Unit: UET 2.1
Subject : Documentary research and dissertation design
VHS: 10:30 PM (Class: 1 hour 30 minutes)
Credits: 1
Coefficient: 1

Teaching objectives :

To equip students with the necessary tools to find relevant information and effectively utilize it in their final year project. To guide them through the various stages of writing a scientific document. To emphasize the importance of communication and teach them how to present their work rigorously and pedagogically.**Recommended prior knowledge:** Writing methodology, Presentation methodology.

Contents of the material:

Part I: Documentary Research:

Chapter I-1: Definition of the subject **(2 Weeks)**

- Subject title
- List of keywords related to the topic
- Gather basic information (acquisition of specialized vocabulary, meaning of terms, linguistic definition)
- The information sought
- To take stock of one's knowledge in the field

Chapter I-2: Selecting Information Sources - Types of Documents **(2 Weeks)**

(Books, Theses, Dissertations, Journal Articles, Conference Proceedings, Audiovisual Documents…)

- Type of resources (Libraries, Internet…)
- Evaluate the quality and relevance of information sources

Chapter I-3: Locating the documents **(Week 1)**

- Research techniques
- Search operators

Chapter I-4: Processing Information **(2 Weeks)**

- Work organization
- The initial questions
- Summary of selected documents
- Links between different parts
- Final plan for the literature review

Chapter I-5: Presentation of the bibliography **(Week 1)**

- Systems for presenting a bibliography (The Harvard system, The system Vancouver, The mixed system…)
- Presentation of documents.
- Citation of sources

Part II: Dissertation Design

Chapter II-1: Plan and stages of the dissertation **(2 Weeks)**

- Define and delimit the subject (Summary)
- Problem statement and objectives of the dissertation
- Other useful sections (Acknowledgments, Table of Abbreviations…)
- The introduction *(Writing the introduction last)*
- State of the specialized literature
- Formulation of hypotheses
- Methodology
- Results
- Discussion
- Recommendations

Conclusion and outlook

- The table of contents
- The bibliography
- The appendices

Chapter II-2: Writing Techniques and Standards - Formatting. **(2 Weeks)**

Numbering of chapters, figures and tables.

- The cover page
- Typography and punctuation
- Writing. Scientific language: style, grammar, syntax.

-Spelling. Improvement of general language skills in terms of comprehension and expression.

- Back up, secure, archive your data.

Chapter II-3: Workshop: Critical Study of a Manuscript **(Week 1)**

Chapter II-4: Oral Presentations and Defenses **(Week 1)**

- How to Present a Poster
- How to present an oral communication.
- Defense of a thesis

Chapter II-5: How to avoid plagiarism ? **(Week 1)**

(Formulas, phrases, illustrations, graphs, data, statistics,...)

- The quote
- Paraphrase – Include the complete bibliographic reference

Evaluation method: Exam: 100%

Bibliographical references:

1. *M. Griselin et al., Guide to Written Communication, 2nd edition, Dunod, 1999.*
2. *JL Lebrun, Practical guide to scientific writing: how to write for the international scientific reader, Les Ulis, EDP Sciences, 2007.*
3. *A. Mallender Tanner, ABC of Technical Writing: User Manuals, Instructions, Help in line, Dunod, 2002.*
4. *M. Greuter, Writing your thesis or internship report well, L'Etudiant, 2007.*
5. *M. Boeglin, Reading and Writing at University: From the Chaos of Ideas to Structured Text. L'Etudiant, 2005.*
6. *M. Beaud, The Art of the Thesis, Casbah Editions, 1999.*
7. *M. Beaud, The Art of the Thesis, La Découverte, 2003.*
8. *M. Kalika, The Master's Thesis, Dunod, 2005.*