الجمهورية الجزائرية الديمقراطية الشعبية People's Democratic Republic of Algeria

وزارة التعليم

العالي والبحث العلمي

Ministry of Higher Education and Scientific Research

اللجنة البيداغوجية الوطنية لميدان العلوم و التكنولوجيا

National Educational Committee for the field of Science and Technology

ACADEMIC MASTER HARMONIZE

National Program

Field Specialty sector	Sector	Process Engineering
Science And Technologies	***Génie des Procédés***	**Chemical Engineering**

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مواءمة

ماستر أكاديمي

Update 2022

الميدان	الفرع	التخصص
علوم و تكنولوجيا	هندسة الطرائق	هندسة كيميائية

I – Master's identity sheet

Access conditions

(Indicate the license specialties which can give access to the Master)

Sector	Harmonized Master	Access licensesto the master's degree	Ranking according to license compatibility	coefficient
Process Engineering	Chemical engineering	Process Engineering	**1**	**1.00**
		Refining and petrochemicals	**2**	**0.80**
		Energy	**3**	**0.70**
		Valorization of mineral resources	**3**	**0.70**
		Other licenses in the ST domain	**5**	**0.60**

II – Half-yearly organization sheets for teaching in the specialty

MASTER CHEMICAL ENGINEERING
Semester 1

Teaching unit matters	Matters titled	Credits	Coefficient	Weekly hourly volume			Half-yearly Hourly Volume (15 weeks)	Additional Work in Consultation (15 weeks)	Evaluation method	
				Course	Dw	PW			Continuous monitoring	Exam
Fundamental EU Code: UEF 1.1.1 Credits: 10 Coefficients: 5	Unit operations I (distillation, sol-liq extraction- mixing)	6	3	3h00	1h30		67h30	82H30	40%	60%
	Porous and dispersed media	4	2	1h30	1h30		45h00	55h00	40%	60%
Fundamental EU Code: UEF 1.1.2 Credits : 8 Coefficients : 4	Applied thermodynamics	4	2	1h30	1h30		45h00	55h00	40%	60%
	Heat exchangers	4	2	1h30	1h30		45h00	55h00	40%	60%
UE Methodological Code : UEM 1.1 Credits : 9 Coefficients : 5	PW Unit operations I	2	1			1h30	22h30	27h30	100%	
	PWPorous and dispersed media	2	1			1h30	22h30	27h30	100%	
	PW Heat exchangers	2	1			1h30	22h30	27h30	100%	
	Process engineering simulators	3	2	1h30		1h00	37h30	37h30	40%	60%
UE Discovery Code : UED 1.1 Credits : 2 Coefficients : 2	Matter of choice	1	1	1h30			22h30	02h30		100%
	Matter of choice	1	1	1h30			22h30	02h30		100%
UE Transverse Code : UET 1.1 Credits : 1	Technical English and Terminology	1	1	1h30			22h30	02h30		100%

Coefficients : 1										
Total semester 1		**30**	**17**	**13h30**	**6h00**	**5h30**	**375h00**	**375h00**		

Semester 2

Teaching unit Matters	Matters titled	Credits	Coefficient	Weekly hourly volume			Half-yearly Hourly Volume (15 weeks)	Additional Work in Consultation (15 weeks)	Evaluation method	
				Course	Dw	PW			Continuous monitoring	Exam
UE Fondamental Code : UEF 1.2.1 Credits : 10 Coefficients : 5	Unit operations 2	6	3	3h00	1h30		67h30	82h30	40%	60%
	(Humidification-Drying-Evaporation-Crystallization)	4	2	1h30	1h30		45h00	55h00	40%	60%
UE Fondamental Code : UEF 1.2.2 Credits : 8 Coefficients : 4	Adsorption and Membrane Separation Processes	4	2	1h30	1h30		45h00	55h00	40%	60%
	Reaction Engineering 1: Non-ideal Reactors and Bioreactors	4	2	1h30	1h30		45h00	55h00	40%	60%
UE Methodological Code : UEM 1.2 Credits : 9 Coefficients : 5	Ovens and Boilers	4	2	1h30	1h30		45h00	55h00	40%	60%
	PW Numerical analysis	2	1			1h30	22h30	27h30	100%	
	PW Unit operations 2	2	1			1h30	22h30	27h30	100%	
	PW Reaction engineering	1	1			1h00	15h00	15h00	100%	
UE Descovery Code : UED 1.2	Matter of choice	1	1	1h30			22h30	2h30		100%

Credits : 2 Coefficients : 2	Matter of choice	1	1	1h30			22h30	2h30		100%
UE Transverse Code : UET 1.2 Credits : 1 Coefficients : 1	Compliance with standards and rules of ethics and integrity	1	1	1h30			22h30	2h30		100%
Total semester 2		**30**	**17**	**13h30**	**7h30**	**4h00**	**375h00**	**375h00**		

Semester 3

Teaching unit matters	**Matters titled**	**Credits**	**Coefficient**	**Weekly hourly volume**			**Half-yearly Hourly Volume (15 weeks)**	**Additional Work in Consultation (15 weeks)**	**Evaluation method**	
				Course	**Dw**	**PW**			**Continuous monitoring**	**Exam**
UE Fondamental Code : UEF 2.1.1 Credits : 10 Coefficients : 5	Fundamentals of process engineering modeling	4	2	1h30	1h30*		45h00	55h00	40%	60%
	Refining and Petrochemical Processes	4	2	1h30	1h30		45h00	55h00	40%	60%
	Process intensification	2	1	1h30			22h30	27h30		100%
UE Fondamental Code : UEF 2.1.2 Crédits : 8 Coefficients : 4	Optimization methods in process engineering	4	2	1h30	1h30		45h00	55h00	40%	60%
	Multiphase reactors	4	2	1h30	1h30		45h00	55h00	40%	60%
UE Methodological Code : UEM 2.1 Credits : 9 Coefficients : 5	Process regulation and control	4	2	1h30	1h30		45h00	55h00	40%	60%
	Experiment plans	3	2	1h30		1h00	37h30	37h30	40%	60%
	PW Refining and petrochemicals	2	1			1h30	22h30	27h30	100%	
UE Discovery	Matter l of choice	1	1	1h30			22h30	2h30		100%

Code : UED 2.1 Credits : 2 Coefficients : 2	Matter of choice	1	1	1h30			22h30	2h30		100%
UE Transverse Code : UET 2.1 Credits : 1 Coefficients : 1	Documentary research and dissertation design	1	1	1h30			22h30	2h30		100%
Total semester 3		**30**	**17**	**15h00**	**7h30**	**2h30**	**375h00**	**375h00**		

N.B. For the fundamental subject of modeling in process engineering, the teacher can provide applications in the form of practical work.

Basket of choice for UED subjects (S1, S2, S3)

1. Green Chemistry – Clean Processes
2. Physico-chemical methods of analysis
3. Corrosion and protection of installations
4. Activation process
5. Energy storage
6. Renewable energies
7. Biomass and biofuels
8. Techno-economic evaluation of processes
9. Environmental management
10. Renewable energies
11. Industrial risks and natural disasters
12. Chemical and Biochemical sensors
13. Biofuel cells
14. Oil Cybernetics

Semester 4

Internship in a company or in a research laboratory culminating in a dissertation and a defense.

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

This table is given for information purposes only.

Evaluation of the End of Master Cycle Project

- Scientific value (jury assessment) /6
- Writing of the dissertation (jury assessment) /4
- Presentation and response to questions (Jury assessment) /4
- Appreciation of the supervisor /3
- Presentation of the internship report (Jury assessment) /3

III - Detailed program by Matter for the S1 semester

Semester: 1
Teaching unit: UEF 1.1.1
Matter 1: Unit operations 1 (distillation, solid-liquid extraction - mixing)
HVW: 67h30 (Course: 3h00, Dw: 1h30)
Credits: 6
Coefficient: 3

Teaching objectives:

At the end of this course, the student should be able to:

- Master the separation techniques of Process Engineering (distillation extraction) and the techniques and mixing
- Address the notions of sizing and design of equipment.
- Know the main operating problems (priming, clogging, etc.).

Recommended prior knowledge:

Thermodynamics, Differential equations, Transfer phenomena (material transfer, fluid mechanics, etc.).

Matter content:

Chapter 1. Distillation **(7Weeks)**

- Reminder on liquid-vapor equilibria
- Flash distillation, Bubble point, Dew point,

Distillation of binary mixtures:

- McCabe and Thiele method: Lewis hypotheses. Operating lines of the rectification and exhaustion sections; thermal lines of the feed, Determination of the number of theoretical stages optimal location of the feed, partial condenser-partial reboiler, Limit cases (total reflux, minimum reflux). Multiple feeds and withdrawals. Murphree Effectiveness- Overall Effectiveness.
- Ponchon Savarit method: Enthalpy-concentration diagram. Material balances and enthalpy balances on the enrichment and exhaustion zones and over the entire column. Optimal position of the feed. Minimum number of theoretical stages. Minimum reflux. Partial condenser. Case of two power supplies

Chapter 2.Liquid-solid extraction (Leaching) **(5 Weeks)**

Solid-liquid equilibrium. Janecke diagram. Determination of the number of theoretical stages, case of counter-current and cross-current extraction. Equipment used continuously and discontinuously.

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

Applications (mixing and dispersion). Different types of agitators. Calculation of Reynolds, power number, Froude number, sizing of a stirring system (diameter of the agitator, number of baffles, power, positioning of the agitator).

Evaluation mode: Continuous assessment: 40%; Exam: 60%.

Bibliographic references:

Daniel Defives et Alexandre Rojey, Transfert de matière , Efficacité des opérations de séparation du génie chimique, Edition TECHNIP ,1976.

1. *Robert E. Treybal,«Mass Transfer Operations»,Third Edition, McGraw –Hill ,1980.*
2. *Warren L. Mc Cabe,Julian C. Smith, Peter Harriott«Unit Operations of Chemical Engineering », Mc Graw-Hill, Inc, Fifth Edition, 1993.*
3. *Jean LEYBROS, Extraction liquide-liquide - Description des appareils, Techniques de l'ingénieur Référence J2764 v1, 2004.*

4. Unit Operations Handbook, Volume 1, Mass transfer, Edited by John J. Mcketta, 1993.
6. Daniel Morvan, Génie Chimique : les opérations Unitaires procédés Industriels Cours et Exercices Corrigés,Editeur : ELLIPSES, Colletion :Technosup, 2009.
7. Pierre Wuithier, Le pétrole ,Raffinage et Génie chimique, 2 ème édition, 1972.

Semester 1
Teaching unit: UEF 1.1.1
Matter 2: Porous and dispersed media
HVW: 45h00 (Course: 1h30, Dw: 1h30)
Credits: 4
Coefficient: 2

Teaching objectives : the objectives of this matter are to provide knowledge of the characteristics of porous and dispersed media as well as their impact on the parameters optimizing solid-liquid contact unit operations, such as sedimentation speed, pressure losses, fluidization speed, etc.

Recommended prior knowledge: basic mathematics; the surfaces of geometric shapes, notions of fluid mechanics; flows, certain unit operations, etc.

Recommended prior knowledge:
Unit operations

Mattet content:

Chapter 1. Operations on solids

Definitions. Grain morphology and stacking. Properties of solids. Grinding. Screening. Sieving.

Chapter 2. Movements of particles in a fluid

Flow of fluids around grains. Vertical movement of particles or globules in the field of gravity. Equation of motion (terminal velocity). Collective fall of particles in a fluid.

Chapter 3. Flow of fluids through a porous medium

Flow of a single fluid through a bed. Dispersion. Heat transfer in a fixed bed. Filled columns. Flow of a suspension. Constant flow filtration. Constant pressure filtration. Law of Ruth. Case of compressible cakes.

Chapter 4. Fluidization

Characteristics of fluidized systems. Liquid-solid systems. Gas-solid systems. Fluidized beds (gas-solid). Transfer of heat and matter between the fluid and the particles.

Chapter 5.Sedimentation

Sedimentation of fine particles. Sedimentation of large particles. Kynch theory. Sizing a decanter.

Chapter 6. Filtration

Filtration theory. Filtration at constant flow, constant pressure. Ruth's law. Case of compressible cakes.

Evaluation method: Continuous assessment: 40%; Exam: 60%.

Bibliographic references Coulson J.M., J.F Richardson, J.R Backhurst And J.H. Harker, "Chemical Engineering", volume two, Fifth edition, Pergamon Press, 2002.

1. Rhodes, M., Introduction to ParticleTechnology, 2nd Ed., Wiley (2008).
2. Gibilaro, L. G., Fluidization - Dynamics, Butterworth - Heinemann (2001).
3. Perry R. H., D. W. Green And J. O. Maloney, "Perry's Chemical Engineers' Handbook " seventh edition, , McGraw Hill, 1999
4. Kunii D. And O. Levenspiel, "Fluidization Engineering", second ed. Butterworth—Heinemann, 1991.
5. Darton R.C., "Fluidization", ed. by J.F. Davidson, R. Clift and D. Harrison, Academic Press, 1985.
6. McCabe W.L., J.C. Smith and P. Harriott, "Unit Operations of Chemical Engineering", seventh edition, ed. McGraw-Hill, 2004.

Semester: 1
Teaching unit: UEF 1.1.2
Matter 1:Applied thermodynamics
HVW: 45h00 (course: 1h30, Dw : 1h30)
Credits: 4
Coefficient:2

Teaching objectives:

Study thermodynamic cycles and master the operating principles of certain energy technologies, namely: thermal machines, compressors, pumps, etc.

Recommended prior knowledge: Chemical thermodynamics, fluid mechanics.

Matter content:

Chapter 1. Turbomachines (07 weeks)

I.1 Pumps

I.2 Fans

I.3 Compressors

I.4 Gas and steam turbines

Chapter 2. Thermodynamic cycles (04 weeks)

II.1Thermodynamic cycle and representation in the diagrams ((T,S), (P,V)…)

II.2 Motor cycles (Rankine, Hirn, Carnot, etc.) and refrigeration cycles (Carnot Inversé, etc.)

II.3 Introduction to Heating and Air Conditioning Systems

II.4 Heat pumps and energy cogeneration

Chapter 3. Thermodynamics of irreversible processes (04 weeks)

IV.1 Energy conservation in open systems

IV.2 Entropic balance of an open system

IV.3 Physical and chemical exergy

IV.4 Application of exegetical analysis to thermodynamic cycles

Evaluation method: Continuous monitoring: 40%; Exam: 60%.

Bibliographic references:Gordon Van Wylen, Richard Sonntag, Thermodynamique appliquée, Editeur Erpi, Collection : Diffusion Pearson Education, 2002.

1. *https://hal.inria.fr/file/index/docid/556977/filename/CycleThermoMachines_1011.pdf*
2. *http://www.emse.fr/~bonnefoy/Public/Machines_Thermiques-EMSE.pdf*
3. *Olivier Cleynen, Thermodynamique de l'ingénieur, Collection Frama book, 2015.*
4. *Paul Chambadal, la turbine à gaz, Collection de la direction des études et recherches d'électricité de France, EYROLLES, 1976.*
5. *Jean Lemale, Les pompes à chaleur, 2éme Edition DUNOD, Paris, 2012, 2014.*
6. *Smith, E.B, Basic, ChemicalThermodynamics, 2nd ed., ClarendonPress, Oxford, 1977.*
7. *Stanley I.Sandler, Chemical and Engineering Thermodynamics, Wiley, New York, 1977.*
8. *Lewis G.N., Randal M., Thermodynamics, Mac Graw Hill*
9. *Hougen O.A., Watson K.M., Chemicalprocessprinciples, Vol II: Thermodynamics, John Wiley and sons*
10. *Brodyanski V., Sorin M., Le Goff P. The efficiency of industrialprocesses, exergyanalysis and optimization, Amsterdam, Elsevier, (1994).*
11. *Wuithier, P, le pétrole, raffinage et génie chimique, édition technip 1972*
12. *Abbott M; Théorie et applications de la thermodynamique, série schum, Paris 1978*
13. *Kireev, V. Cours de chimie physique, Edition Mir, Moscou 1997*

Semester: 1
Teaching unit: UEF 1.1.2
Matter2: Heat exchangers
HVW: 45h00 (Course: 1h30, Dw: 1h30)
Credits: 4
Coefficient:2

Teaching objectives:

Complete students' knowledge and teach them new concepts such as heat transfer in transient conditions, conduction through fins and in the presence of a heat source as well as heat exchangers, and calculation methods for heat exchanger equipment. heat transfer.

Recommended prior knowledge:

Heat transfer, fluid mechanics, notions of mathematics (first and second order differential equations, calculation of integrals, etc.).

Matter content:

Chapter 1. Reminders of the Laws of Heat Transfer (1 Week)
Chapter 2: flow around an obstacle (04 weeks)
- Flow on a flat plate, flow around a tube, cylinder, sphere, correlations and estimation of the heat transfer coefficient
- Flow around a pack of tubes, correlation
Chapter 3: Flow in the tubes (03 weeks)
- Correlations and estimation of the heat transfer coefficient
Chapter.4: Description of heat exchange devices without Phase change (1 week)
Double-tube exchangers, Shell and shell exchangers (shell, shell and shell-shell assembly) and Plate heat exchangers.

Chapter 5.Calculation of Exchangers (3 Weeks)
Study of heat transfer (fundamental equations, average temperature difference, overall transfer coefficient U), Study of pressure losses (Pressure loss inside the tubes, Pressure loss outside the tubes), Methods of calculation (Calculation of a double-tube exchanger, Calculation of a beam and shell exchanger (Kern method)), General considerations on the calculation of a beam and shell device and programming of the calculation.

Chapter 6. Heat Exchange Devices with Phase Change (3 Weeks)
Description of devices, condensation of a pure vapor (Film coefficients for condensation outside the tubes, Calculation of the condenser, Condensation preceded by desuperheating of the vapor and followed by cooling of the condensate), Condensation of a vapor complex (Calculation of the own transfer coefficient (Ward's method and Kern's method), Pressure loss in the calender, Calculation example), flooded reboilers with forced circulation (Reboiling of a pure body in the calender, Reboiling of a mixture in the calender), Level Reboilers with Natural Circulation, Flooded Reboilers with Natural Circulation, example of Calculation of a Reboiler.

Evaluation mode: Continuous monitoring: 40%; Exam: 60%.

Bibliographic references:

1. *J.F. Sacadura, Transferts thermiques – Initiation et approfondissement, Ed. Lavoisier, 2015.*
2. *R.B Bird, W.E. Stewart, E.N. Lightfoot, Transport phenomena, 2ème Ed., Wiley & Sons, 2007.*
A. Giovannini et B. Bédat, Transfert de chaleur, Ed. Cépaduès, 2012.

3. *James R. Welty, Charkes E. Qicks, Robert E. Wilson; Gregory Rorrer, Fundamentals of Momentum, Heat, and Mass Transfer. 4thedition Wiley& Sons, 2001.*
4. *Leontiev, Théorie des échanges de chaleur et de masse – Édition Mir-Moscou*
5. *H.W. Mac Addams La transmission de la chaleur - Dunod - Paris*
6. *F. P. Incropera, D. P. Dewitt - Fundamentals of Heat and Mass Transfer - Wiley, N.Y. - 2002*
7. *Bontemps, A. Garrigue, C. Goubier, J. Huetz, C. Marvillet, P. Mercier Et R. Vidil – Échangeur de chaleur – Technique de l'Ingénieur, Traité Génie Énergétique*
8. *P. Wuithier, Le Pétrole, Raffinage et Génie Chimique tome2, Edition technip Paris*

Semester: 1
Teaching unit: UEM1.1
Matter 1: Unit operations practical work I
HVW: 22:30 H. (PW: 1:30H.)
Credits: 2
Coefficient:1

Teaching objectives:

• Allow the student to apply the theoretical knowledge acquired on a practical level and to visualize certain phenomena.

• Know how to work in a team, respect safety rules and control risks linked to materials, installations and processes.

Recommended prior knowledge:

Thermodynamics, Transfer phenomena (material transfer, fluid mechanics, etc.).

Matter content:

PWNº. 1. Determination of the mutual solubility of two partially miscible liquids, water-phenol.

PW Nº. 2. Extraction of caffeine from tea.

PW Nº. 3. Separation of benzoic acid and 2-naphthol

PW Nº. 4. Study of a batch liquid-liquid extraction process.

PW Nº. 5. Study of some phase diagrams**.**

PW Nº. 6. Absorption of CO2 contained in an air flow by water ("physical" absorption).

PW Nº. 7. Absorption with chemical reaction and regeneration of the solvent: absorption of CO_2 in amino acids.

PW Nº. 8. Liquid-gas absorption desorption**.**

PW Nº. 9. Creation of a water/oil/surfactant ternary diagram.

Evaluation mode: Continuous monitoring: 100%.

Semester: 1
Teaching unit: UEM1.1
Matter2: PW porous and dispersed media
HVW: 22h30 (PW: 1h30)
Credits: 2
Coefficient: 1

Teaching Objectives

- **P**ut into practice the theoretical notions acquired in the subject.
- Know how to start, operate, and stop an installation following safety rules.

Recommended prior knowledge: Unit Operations

Matter Content :

PW Nº. 1. Characterization of solid particles: bulk density, bed porosity, flow angles.

PW Nº. 2. Determination of average diameters by sieving.

PW Nº. 3. Measurement of pressure drop across a bed of particles; fluidization.

PW Nº. 4. Gas-solid or liquid-solid fluidization: minimum fluidization velocity, heat transfer, bed expansion.

PW Nº. 5. Filtration: filtration on a filter press, cake and cloth resistance.

PW Nº. 6. Grinding.

Mode of assessment: Continuous assessment: 100%

Semester: 1
Teaching unit: UEM1.1
Matter 3:PW Heat exchangers
HVW: 22h30 (PW: 1h30)
Credits: 2
Coefficient : 1

Teaching objectives:
- Experimentally quantify the various modes of heat transfer.
- Measure the thermal performance of different types of exchangers.
- Experimentally study equipment for the production, transport and use of steam.

Recommended prior knowledge:

Transfer phenomena, fluid mechanics.

Matter content:

PW Nº. 1. Heat transmission by conduction (basic unit).
*
PW Nº. 2. Linear heat conduction**.**

PW Nº. 3. Radial heat conduction.

PW Nº. 4. Convection and radiation

PW Nº. 5. Heat transmission by free and forced convection.

PW Nº. 6. Coaxial heat exchanger.

PW Nº. 7. Plate heat exchanger: enthalpy balances, efficiency curves, evaluation of transfer coefficients.

PW Nº. 8. Tube bundle heat exchanger.

Evaluation mode: Continuous monitoring:100%.

Semester: 1
Teaching unit: UEM 1.1
Matter 4: Simulators in Process Engineering
HVW: 37h30 (Course : 1h30, PW: 1h00)
Credits: 3
Coefficient : 2

Teaching objectives:
Through this subject, the student learns to design, size and simulate certain industrial processes in relation to process engineering using a calculation code in the form of a simulator. The program will be adapted according to the simulator used.

Recommended prior knowledge:
Thermodynamics, Transfer phenomena, Unit operations

Matter Content:

Chap. I: Reminder (2 weeks)
Process engineering simulators, creation of a simulation, selection of the list of compounds, choice of the thermodynamic model, installation and specification of material flows, simulation of pumps, compressors and flash separator.

Chap. II: Simulation of reactions and chemical reactors/bioreactors (3 weeks)
Single Conversion Reactions, Multiple Conversion Reactions, Balanced Reactions, Perfectly Stirred Reactors (RPR), Plug Reactors (RP), Bioreactors, Catalytic Reactors and Reactor Association.

Chap. III: Simulation of gas-liquid, liquid-liquid contactors and liquid-solid (3 weeks)
Simulation of absorption/striping phenomena without and with chemical reactions in columns of different configurations (trays and packings), liquid-liquid and liquid-solid extraction.

Chap. IV: Simulation of distillation columns (3 weeks)
Distillation of binary and complex mixtures in columns of different configurations (plate and packed column with total and partial reflux and total and partial condenser).

Chap. V: Simulation of real processes (4 weeks)
Applications to different real chemical pr**ocesses**

Evaluation method: Continuous monitoring: 40%; Exam: 60**%.**

Bibliographic references:1- Mariano Martín Martín, Introduction to Software for ChemicalEngineers, 2014.
2- Xavier Julia, Simulateurs de procédés, techniques de l'ingénieur, J1022 V2.
3- User guide du simulateur utilisé.

Semester: 1
Teaching unit: UED1.1
Matter 1: Green Chemistry-Clean Processes
HVW: 22h30 (Course: 1h30)
Credits: 1
Coefficient:1

Teaching objectives:
Develop information management methods with the aim of structuring and capitalizing on data in order to quickly and faithfully access solutions allowing the evolution of the production process towards a clean process using the least amount of material and energy while taking into account environmental protection.

Recommended prior knowledge: Basic notions of process engineering

Matter Content:

Chapter 1: Green chemistry (2 weeks)
• The principles of green chemistry
Chapter 2: Tools for clean process engineering (5 weeks)
• Sustainable process design methodology: a multi-criteria approach. Concept of sustainable development in Process Engineering. System boundaries. Design of sustainable processes.
• Process optimization strategies. Examples of studies and resulting types of optimization. Optimization methods.
• Representation and modeling of processes. IT aspect. Representation of phenomena by bond graphs. Application of connection graphs to process engineering: case of finite-dimensional systems. Application of connection graphs to process engineering: case of infinite-dimensional systems.
Chapter 3: Innovative technologies and methods for intensification (4 weeks)
• Miniaturization of processes. Principles of intensification by miniaturization. Miniaturized mixers, contactors and exchangers. Some examples of industrial applications.
• Multifunctional reactors.
• Ultrasound in process engineering (sonochemical engineering)
• Microwaves in process engineering
• Intensification through formulation.
Chapter 4: New generation of processes (4 weeks)
Supercritical fluids. Ionic liquids. Water as solvent and reactions without solvent. Electrochemical processes for sustainable development. Photocatalytic engineering. Biocatalysis and Bioprocesses. Contributions of catalysis to sustainable chemistry.

Evaluation method: Exam: 100%.

Bibliographic references:

1. *S. Suresh, S. Sundaramoorthy, Green Chemical Engineering. An Introduction to Catalysis, Kinetics, and Chemical Processes, CRC Press, 2015.*
2. *Paul T. Anastas, Handbook of Green Chemistry. Green Processes, Volume Editors: Robert Boethling, AdelinaVoutchkova, Volume 9: Designing Safer Chemicals, Wiley-VCH, 2012.*
3. *Martine Poux, Patrick Cognet, Christophe Gourdon, Green Process Engineering from Concepts to Industrial Applications, CRC Press, 2010.*

Semester: 1
Teaching unit: UET1.1
Matter 1: Physico-chemical methods of analysis
HVW: 45h00 (Course: 1h30, Dw: 1h30)
Credits: 2
Coefficient:2

Teaching objectives:
Provide fundamental knowledge of the experimental methods and techniques that make it possible to characterize matter and study its structure. In particular techniques and tools for which technological progress has recently appeared.

Recommended prior knowledge:
State of matter, chemical thermodynamics, structural and physicochemical properties of matter, notions of physics and general chemistry.

Matter content:

Chapter 1. Separative techniques: Chromatography: (2 Weeks)
General aspects, Classification of chromatographic techniques: column chromatography and plate chromatography.

Chapter 2. Types of Chromatography (3 Weeks)
GC, HPLC, TLC.
Chapter 3. Coupled methods: GC/MS. LC/MS (2 Weeks)
Chapter 4. Atomic absorption spectrometry:
General, instrumentation and applications; Method of dosed additions **(2 Weeks)**
Chapter 5. Atomic emission spectrophotometry (2 Weeks)
General, instrumentation and applications; Internal standard method

Chapter 6. X-ray fluorescence spectrometry (2 Weeks)
General, applications and advantages

Chapter 7. Thermal analysis: instrumentation and techniques (2 Weeks)

Evaluation method: Continuous monitoring: 40%; Exam: 60%.

Bibliographic references:

1- *J. Tranchant, Manuel pratique de chromatographie en phase gazeuse, Masson, Paris 1995.*
2- *F. Rouessac et A. Rouessac, Méthodes et techniques instrumentales modernes, Dunod, Paris 2004.*
3- *P. Arnaud, Chimie organique, Dunod, 2009.*
4- *A.Skoog, F.Holler et A. Niemaw, Principes d'analyse instrumentale, Edition de Boeck, Paris 20*

Semester: 1
Teaching unit: UET1.1
Matter1: Technical English and terminology
HVW: 22h30 (Course: 1h30)
Credits: 1
Coefficient: 1

Teaching objectives:
Introduce the student to technical vocabulary. Strengthen your knowledge of the language. Help them understand and synthesize a technical document. Allow him to understand a conversation in English held in a scientific framework.

Recommended prior knowledge:
Basic English vocabulary and grammar

Matter content:

- Written comprehension: Reading and analysis of texts relating to the specialty.

- Oral comprehension: From authentic popular science video documents, note taking, summary and presentation of the document.

- Oral expression: Presentation of a scientific or technical subject, development and exchange of oral messages (ideas and data), Telephone communication, Gestural expression.

- Written expression: Extracting ideas from a scientific document, Writing a scientific message, Exchange of information in writing, writing CVs, letters requesting internships or jobs.

Recommendation: It is strongly recommended that the person responsible for the subject presents and explains at the end of each session (at most) around ten technical words from the specialty in the three languages (if possible) English, French and Arabic.

Evaluation method: Continuous monitoring 100%.

Bibliographic references:

1. *P.T. Danison, Guide pratique pour rédiger en anglais: usages et règles, conseils pratiques, Editions d'Organisation 2007*
2. *A. Chamberlain, R. Steele, Guide pratique de la communication: anglais, Didier 1992*
3. *R. Ernst, Dictionnaire des techniques et sciences appliquées: français-anglais, Dunod 2002.*
4. *J. Comfort, S. Hick, and A. Savage, Basic Technical English, Oxford University Press, 1980*

III - Detailed program by matter for the S2 semester

Semester: 2
Teaching unit: UEF 1.2.1
Matter 1: Unit operations 2 (Humidification, Drying-Evaporation-Crystallization)
HVW : 67h30 (Course: 3h00, DW: 1h30)
Credits: 6
Coefficient: 3

Teaching objectives:
At the end of this module, the student will have acquired the knowledge necessary to understand the phenomena of simultaneous transfer of matter and heat and to size certain equipment.

Recommended prior knowledge:
Knowledge of transfer phenomena (matter, quantity of movement and heat), thermodynamics, mathematics and unit operations studied in bachelor's degree.

Matter content:
Chapter 1. Humidification (6 Weeks)
Principle. Applications. Wet sizes. Equipment used (cooling tower, air cooler). Humid air diagrams. Wet thermometer. Humid air mixture (calculation of the humid quantities of the mixture, Mollier diagram (enthalpy, absolute humidity). Sizing of a cooling tower.
Chapter 2. Drying (3 Weeks)
General. .Different types of dryers. Choice of dryers. Drying mode (continuous, discontinuous, counter-current, co-current, by convection, conduction etc.). Drying mechanisms. Material and enthalpy balance at the level of a dryer. Calculation of drying speed and duration.
Chapter 3. Evaporation (3 Weeks)
Introduction. Main factors influencing evaporation. Heat and material balance at the evaporator level (simplified). Different types of evaporators and different circulations. Calculation of the exchange surface (simplified or multiple-effect evaporator). Comparison between counter-current and co-current multi-effect evaporation). Different types of evaporation processes (compression system, ejecto-compression, heat pump, absorption). Additional devices (condensers, gas-liquid separator).
Chapter 4. Crystallization (3 Weeks)
Some fundamental aspects. The different stages of crystallization. Effect of impurities on crystal formation. Crystallization reactors (Batch and continuous). Adsorption of a solute in the liquid phase in a fixed bed tower (percolation).

Evaluation method: Continuous monitoring: 40%; Exam: 60%.

Bibliographic references:

Daniel Morvan, Génie Chimique : les opérations Unitaires procédés Industriels Cours et Exercices Corrigés, Editeur : ELLIPSES, Colletion :Technosup, 2009.

1. *Warren L. MCCabe,Julian C. Smith,, Peter Harriott « Unit Operations of Chemical engineering », Seventh Edition MC Graw Hill,2005.*
2. *Unit Operations Handbook, Volume 1, Mass transfer, Edited by John J. Mcketta, 1993.*
3. *Robert E. Treybal,«Mass Transfer Operations»,Third Edition, McGraw –Hill ,1980.*
4. *Georges Arditti, Technologie chimique industrielle, Tome 3, Production de la chaleur Transfert de matière utilisant l'énergie, Editions EYROLLES, 1972.*

Semester: 2
Teaching unit: UEF 1.2.1
Matter 2: Adsorption processes and Membrane separation
HVW: 45h00 (Cours: 1h30, TD: 1h30)
Credits: 4
Coefficient:2

Teaching objectives:

The objective is to give:
- The theoretical bases necessary to implement an adsorbent and the sizing of adsorbers of various types: discontinuous, semi-continuous and continuous.
- In-depth theoretical and practical knowledge in the field of membrane techniques and familiarize them with the latest technological advances in membranes.

Recommended prior knowledge:
Transfer phenomena (material transfer, fluid mechanics, etc.), surface chemistry and heterogeneous catalysis.

Matter content:

First part: Adsorption processes **(6 Weeks)**

Chapter 1. Main industrial adsorbents, selection criteria, regeneration methods, main industrial applications.
Chapter 2. Dynamics of adsorption (preceded by a reminder of the general laws of physical adsorption).
Chapter 3. Discontinuous processes.
Chapter 4.
Adsorption separation processes
- Pressure modulated.
-Temperature modulated.

Part two: Membrane separation processes

Chapter 1. Generalities and definitions **(1 Weeks)**
Chapter 2. Membranes **(3 Weeks)**
Structure, characterization and membrane modules of industrial installations.
Chapter 3. Membrane separation technique **(5 Weeks)**
Microfiltration, Ultrafiltration, Nanofiltration, Reverse osmosis and electrodialysis.

Evaluation method: Continuous monitoring: 40%; Exam: 60%.

Bibliographic references:

Unit Operations Handbook, Volume 1, Mass transfer, Edited by John J. Mcketta, 1993.
Warren L. Mc Cabe,Julian C. Smith, Peter Harriott«Unit Operations of Chemical Engineering », Mc Graw- Hill, Inc, Fifth Edition, 1993.
J. P. Brun, Procédés deséparation par membranes, Transport Techniques membranaires Applications, Masson, Paris, 1988.
Robert E. Treybal,«Mass Transfer Operations»,Third Edition, McGraw –Hill ,1980.

Semester: 2
Teaching unit: UEF 1.2.2
Matter 1: Reaction Engineering I: Non-ideal Reactors and Bioreactors
HVW: 45h00 (Course: 1h30, DW: 1h30)
Credits: 4
Coefficient:2

Teaching objectives: The student will have acquired knowledge concerning hydrodynamics in real or non-ideal reactors, the main models of homogeneous reactors and notions of the operation of bioreactors.

Recommended prior knowledge:
Knowledge of basic concepts in chemical kinetics, thermodynamics, transfer phenomena and ideal homogeneous reactors**.**

Matter content:

Chapter 1: Non-ideal reactors (7 weeks)
- fundamental notions (introduction and definitions)
- Modeling of reactors: concept of residence time distributions (DTS),
- identification of reactors, non-isothermal reactors, adiabatic reactors, simple models: axial dispersion piston reactor, models with several parameters, aggregation states (micro and macro mixing).

Chapter 2 Bioreactors (8 weeks)
- Classification and characteristics of bioreactors
- Material transfer in bioreactors: transfer-reaction coupling,
- mechanism and kinetics of homogeneous and heterogeneous enzymatic reactions
- Operating mode of bioreactors (perfectly stirred continuous reactors, fixed bed reactors, fluidized bed reactors, membrane reactors).

Evaluation method : Continuous monitoring: 40%; Exam: 60%.

Bibliographic references:
Levinspiel O : chemicalreaction engineering, 3ème édition, John Wiley and Sons, New York (1998) ISBN : 0471225424X
Villermaux J : Génie de la réaction chimique, conception et fonctionnement des réacteurs, 2ème édition, Tec § Doc Lavoisier , Paris (1993) ISBN : 2-85206-132-5
Schweich D : génie de la réaction chimique, Tec ! Doc lavoisier (2001) ISBN : 2-7430-0459-2
Froment G and BischoffKB : Chemical reactor, analysis and design : John Wiley and Sons, New York (1979) ISBN : 978-0471510-444
P.trambouze : les réacteurs chimiques : conception / calcul/mise en œuvre, Editions Technip(Paris) 1984
R.W.Missen : chemicalreaction engineering and kinetics, Edition John Wiley and Sons, Inc, New York, 1999

Semester: 2
Teaching unit: UEF 1.2.2
Matter 2: Furnaces and Boilers
HVW: 45h00 (Course: 1h30, DW: 1h30)
Credits: 4
Coefficient:2

Teaching objective:
Explain the operation of industrial furnaces and boilers.

- ✓ establish an energy balance of an oven or boiler and determine the thermal efficiency of the equipment.
- ✓ Indicate the areas of energy loss in this equipment and the methods for optimizing the heat balance.
- ✓ Describe the main operating operations of heating equipment.

Recommended prior knowledge:

- ✓ Phenomena of transfer of matter, heat and momentum, and thermodynamics.

Matter content:

Chapter 1. INTRODUCTION (1 Weeks)
Chapter 2. FUELS AND COMBUSTION ENERGY (4 Weeks)
Fuels; Combustion. ; Combustion reaction; Combustion quality. ; Combustion equipment; Environmental aspects linked to combustion.

Chapter 3. INDUSTRIAL OVENS (6 Weeks)
- Classification and description of industrial ovens.
Continuous furnaces, discontinuous furnaces, direct heating and indirect heating, High and low temperature furnaces, sizing of a furnace.
- Energy balance of an oven.
- Yield of an oven.
- Operation of industrial ovens (main operations):
  Drying, Commissioning and control of operation and shutdown of a furnace, Decoking of furnace tubes.

Chapter 4. INDUSTRIAL BOILERS (4 Weeks)
4.1. Role of industrial boilers.
4.2. Thermodynamic aspect of boilers.
4.3. Different types of boilers
Water tube boilers, Fire tube boilers, Recovery boilers.
4.4. Water circulation in boilers.
4.5. Thermal calculation of a boiler.
4.6. Main parameters to monitor when operating a boiler.

Evaluation method: Continuous monitoring: 40%; Exam: 60%.

Bibliographic references:

R.Borghi, M.Destriau, , Gérard de Soete, Combustion and Flames, Chemical and physicalprinciples, Edition TECHNIP, 1998.
R.Borghi, M.Destriau, Gérard de Soete, La combustion et les flammes, Edition TECHNIP, 1995.
http://www.ultimheat.com/Museum/section3/1932%20ca%20Galopin%20chaudi%C3%A8res%2020111015.pdf
Irvin Glassman, Combustion, Second edition , ACADEMIC PRESS, INC, 1987.
Georges Monnot, La Combustion dans les fours et les chaudières, Technip, Publications de l'Institut français du pétrole, 1978.

Semester: 2
Teaching unit: UEM 1.2
Matter 3: Numerical Analysis
HVW: 45h00 (Course: 1h30, Dw: 1h30)
Credits: 4
Coefficient : 2

Teaching objectives:
Study basic methods of numerical analysis.

Recommended prior knowledge:
Analysis Course, Differential Equations….

Matter content:

Chapter 1: Introduction
- Mathematical Modeling of the Transport Phenomenon
  Conservation principle, Continuity equation, Energy equation, Conservation equation of chemical species.

Chapter 2: Classification of Partial Differential Differential Equations
- Classification in the mathematical sense.
- Classification in the physical senses.

Chapter 3: Discretization Methods
- Finite difference method (detailed).
- Finite volume method (detailed).
- Finite element method.

Chapter 4: Elliptic Equations
- 1D conduction in steady state
  Meshing, Conductivity at interfaces, Linearization of the source term, Boundary conditions and Resolution of linear algebraic equations (TDMA Method).
- 2D and 3D conduction
  Solving algebraic equations (Gauss Seidel Method, Relaxation Method).

Evaluation method: Continuous monitoring: 100%.

References

Semester: 2
Teaching unit: UEM 1.2
Matter 1: PW Unit operations 2,
HVW: 22h30 (PW: 1h30)
Credits: 2
Coefficient:1

Teaching objectives:
• Apply concepts relating to unit operations of Process Engineering, in terms of balances between phases, balances and material transfers.

Recommended prior knowledge:

Thermodynamics, Transfer phenomena, Surface chemistry and heterogeneous catalysis and liquid-liquid extraction.

Matter content:

PW N°. 1. Evaluation of the efficiency of the cooling tower.
PW N°. 2. Procedure for calculating the mass of water lost by the solid.
PW N°. 3. Drying of an organic phase.
PW N°. 4. Spray drying (sodium sulfate): material balances and enthalpy balances, wet temperature
TPW N°. 5. Evaporation of an organic solvent.
PW N°. 6. Purification by recrystallization.
PW N°. 7. Drying of solids.

Evaluation method: Continuous monitoring: 100%.

NB: At least four practical exercises in unit operations are provided depending on the means available, other practical exercises may be adopted with the agreement of the scientific and educational authorities.

Semester: 2
Teaching unit: UEM 1.2
Matter 3: PW reaction engineering
HVW : 22h30 (PW : 1h30)
Credits: 2
Coefficient : 1

Teaching objectives:
Measure the ability of a student to carry out practical work aimed at studying the operation of a reactor using the knowledge acquired during the course or at the start of the practical work and to assess their ability to write a scientific document highlighting the major results obtained.

Recommended prior knowledge:
Homogeneous reactor, transfer phenomena.

Matter content:

WP Nº. 1. Continuous stirred reactor TP**.**

PW Nº. 2. TP Plug flow reactor.

PW Nº. 3. TP Reactors in series.

PW Nº. 4. Bioproduction: production of ethanol by fermentation.

PWNº. 5. Photosynthesis: Demonstration of gas exchanges with aquatic plants

Evaluation methd: Continuous monitoring:100%.

Semester: 2
Teaching unit: UEM 1.2
Matter 3:PW membrane adsorption and separation processes
HVW: 15h00 (Pw : 1h00)
Credits: 1
Coefficient : 1

Teaching objectives:
Learn to make reliable measurements in adsorption and membrane separations, develop critical thinking, learn to interpret and present your results.

Recommended prior knowledge:

Thermodynamics, Transfer phenomena, Surface chemistry

Matter content:

PW Nº. 1. Separation of a dye in the aqueous phase by adsorption.

PW Nº. 2. Separation of a pesticide in the aqueous phase by adsorption.

PW Nº. 03. Equilibrium in the heterogeneous system: experimental determination of the adsorption isotherm of CH3COOH, dissolved in water, by a solid substance (activated carbon).

WNº. 04. Extraction by emulsified liquid membrane.

WNº. 05. Preparation and stabilization of an emulsion.

Evaluation method: Continuous monitoring: 100%.

NB: At least four TPs in adsorption and membrane separation processes are provided according to the available means, other TPs may be adopted with the agreement of the scientific and educational authorities

Semester: 2
Teaching unit: UET 1.2
Matter: Compliance with standards and rules of ethics and integrity.
HVW : 22h30 (Cours : 1h30)
Credit : 1
Coefficient : 1

Teaching objectives:

Develop students' awareness of respect for ethical principles and the rules that govern life at university and in the world of work. Raise awareness about respecting and valuing intellectual property. Explain to them the risks of moral evils such as corruption and how to combat them, alert them to the ethical issues raised by new technologies and sustainable development.

Recommended prior knowledge:

Ethics and professional conduct (the foundations)

Matter Content

A. Respect for the rules of ethics and integrity,

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

2. Integrity and responsible research
- Respect for the principles of ethics in teaching and research
- Responsibilities in teamwork: Professional equality of treatment. Conduct against discrimination. The search for the general interest. Inappropriate conduct in the context of collective work
- Adopt responsible conduct and combat abuses: Adopt 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 world of work:
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, communications
in a congress, theses, dissertations, etc.)

II- Copyright
1. Copyright in the digital environment
Introduction. Database copyright, software copyright. Specific case of free software.
2. Copyright in the Internet and e-commerce
Domain name law. Intellectual property on the internet. E-commerce site law. Intellectual property and social networks.

3. Patent
Definition. Rights in a patent. Usefulness of a patent. Patentability. Patent application in Algeria and around the world.

III- Protection and valorization of intellectual property
How to protect intellectual property. Violation of rights and legal tool. Valorization of intellectual property. Protection of intellectual property in Algeria.

C. Ethics, sustainable development and new technologies

Link between ethics and sustainable development, energy saving, bioethics and new technologies (artificial intelligence, scientific progress, Humanoids, Robots, drones,

Evaluation method: exam: 100%

Bibliographic references :

Charte d'éthique et de déontologie universitaires, https://www.mesrs.dz/documents/12221/26200/Charte+fran_ais+d_f.pdf/50d6de61-aabd-4829-84b3-8302b790bdce

Arrêtés N°933 du 28 Juillet 2016 fixant les règles relatives à la prévention et la lutte contre le plagiat

L'abc du droit d'auteur, organisation des nations unies pour l'éducation, la science et la culture(UNESCO)

E. Prairat, De la déontologie enseignante. Paris, PUF, 2009.

Racine L., Legault G. A., Bégin, L., Éthique et ingénierie, Montréal, McGraw Hill, 1991.

Siroux, D., Déontologie : Dictionnaire d'éthique et de philosophie morale, Paris, Quadrige, 2004, p. 474-477.

Medina Y., La déontologie, ce qui va changer dans l'entreprise, éditions d'Organisation, 2003.

Didier Ch., Penser l'éthique des ingénieurs, Presses Universitaires de France, 2008.

Gavarini L. et Ottavi D., Éditorial. de l'éthique professionnelle en formation et en recherche, Recherche et formation, 52 | 2006, 5-11.

Caré C., Morale, éthique, déontologie. Administration et éducation, 2e trimestre 2002, n°94.

Jacquet-Francillon, François. Notion : déontologie professionnelle. Le télémaque, mai 2000, n° 17

Carr, D. Professionalism and Ethics in Teaching. New York, NY Routledge. 2000.

Galloux, J.C., Droit de la propriété industrielle. Dalloz 2003.

Wagret F. et J-M., Brevet d'invention, marques et propriété industrielle. PUF 2001

Dekermadec, Y., Innover grâce au brevet: une révolution avec internet. Insep 1999

AEUTBM. L'ingénieur au cœur de l'innovation. Université de technologie Belfort-Montbéliard

Fanny Rinck etléda Mansour, littératie à l'ère du numérique : le copier-coller chez les étudiants, Université grenoble 3 et Université paris-Ouest Nanterre la défense Nanterre, France

Didier DUGUEST IEMN, Citer ses sources, IAE Nantes 2008

Les logiciels de détection de similitudes : une solution au plagiat électronique? Rapport du Groupe de travail sur le plagiat électronique présenté au Sous-comité sur la pédagogie et les TIC de la CREPUQ

Emanuela Chiriac, Monique Filiatrault et André Régimbald, Guide de l'étudiant: l'intégrité intellectuelle plagiat, tricherie et fraude… les éviter et, surtout, comment bien citer ses sources, 2014.

Publication de l'université de Montréal, Stratégies de prévention du plagiat, Intégrité, fraude et plagiat, 2010.

Pierrick Malissard, La propriété intellectuelle : origine et évolution, 2010.

Le site de l'Organisation Mondiale de la Propriété Intellectuelle www.wipo.int

http://www.app.asso.fr/

V- Detailed program by matter for the S3 semester

Semester: 3
Teaching unit: UEF 2.1.1
Matter: foundations of modeling in process engineering
HVW: 45h00 (Course : 1h30,DW: 1h30)
Credits: 4
Coefficient :2

Teaching objectives

Recommended prior knowledge:

Thermodynamics, kinetics, Heterogeneous reactors, heat and matter transfer, Fluid dynamics, numerical analysis

Matter Content:

1. Introduction
2. Definition of modeling
3. Modeling in process engineering
4. The stages of modeling
5. The fundamental laws of modeling in process engineering
5.1 Continuity equations
5.1.1 Global continuity equation
- Applications: continuous stirring reactor; piston reactor
5.1.2 Individual continuity equations
- Applications: continuous stirring reactor; piston reactor
5.2 Energy equation
- Applications: continuous stirring reactor with heat transfer device; piston reactor with heat transfer jacket;
5.3 Momentum equation
- Applications: laminar flow in vertical and horizontal pipes
6. Modeling of a thermodynamic phase equilibrium
6.1 Phase equilibrium criteria
6.1a Equations of state
61b Activity models
- Liquid-liquid balance;
- Liquid-vapor equilibrium;
- Solid-liquid equilibrium
7. Modeling Examples
- Packed extraction column operating against the current;
- Distillation column with plates;
- Trickling absorption column;
- Heat transfer in a metal sphere and cylinder;
- Modeling of liquid-liquid equilibria; liquid-vapor (low and high pressure); solid-liquid

Practical work: Solving models on Excel, Comsol, Matlab, etc.

Evaluation method: Exam: 60%, Continuous monitoring: 40%

Bibliographic references:

:

- Transport Phenomena, by R. Byron Bird Warren E. *Stewart* Edwin N. *Lightfoot*, Second Edition;
- The Principles of Chemical Equilibrium , Kenneth Denbigh;
- Thermodynamics by Jean Vidal, Editions TECHNIP, 1997

Semester: 3
Teaching unit: UEF 2.1.2
Matter 2: Refining and Petrochemical Processes
HVW: 45h00 (Course:1h30, DW: 1h30)
Credits: 4
Coefficient : 2

Teaching objectives:
Mastery of physical, thermal and catalytic processes for transformation and conversion of petroleum cuts into finished products or as a source for petrochemicals.

Recommended prior knowledge:
Thermodynamics, kinetics, Heterogeneous reactors, heat and matter transfer, Fluid dynamics, heat and matter transfer,

Matter content:

Chapter 1. Refining Processes
• Diagram of a classic refinery
• Evolution of refining: environmental and economic constraints
• General information on refining processes,
• Composition of crude oils and petroleum products
• Fractionation (TBP distillation) and characterization of crude oils and petroleum cuts,
• Fractional distillation process for crude oils (atmospheric and vacuum).
• Mixing units (fuels, lubricants, etc.).
• methods for calculating the physical properties of hydrocarbons
• standards and specifications,
• Additives

Chapter 2.Petrochemical processes

• Basic principles governing chemical transformation,
• Industrial catalysts
• Processes for improving properties: catalytic reforming, isomerization, etc.
• Conversion processes: steam cracking, catalytic cracking, etc.
• Finishing processes: hydrogenation, softening, etc.
• Environmental protection processes: smoke treatment, waste water treatment, etc.
• hydrogen production (hydrogen in the refinery, production by steam reforming, by partial oxidation, hydrogen-energy co-production, etc.)
• The different manufacturing schemes in petrochemicals
• Petrochemical products

Application: REFINING PROCESSES -Petrochemicals: Mini project.

Evaluation method: Continuous monitoring: 40%; Exam: 60%.

Bibliographic references:

Le pétrole : Raffinage et Génie Chimique. Tome 1 de J. P Wuithier. Publication de l'Institut Français du Pétrole. Edition Technip ; 01-1972
Pierre Leprince, Alain Chauvel, Jean-Pierre Catry et Lorraine Castex « Procédés de pétrochimie, caractéristiques techniques et économiques »,EditionsTechnip, 1971.

Robert A. Meyers: Handbook of Petroleum RefiningProcesses, Third Edition. © 2012 The McGraw-Hill Companies.
Handbook of Petroleum Processing - ISBN-13 978-1-4020-2820-5 (e-book). © 2008 Springer Science + Business Media B.V
J.-P. Wauquier , Collectif Technip – « Le raffinage du pétrole - Tome 1 - Pétrole brut - Produits pétroliers - Schémas de fabrication », Editeur : Technip, 1998
J.-P. Wauquier , Collectif Technip – « Le raffinage du pétrole -Tome 2 - Procédés de séparation, Editeur : Technip , 1998
P. Leprince, Collectif Technip – « Le raffinage du pétrole -Tome 3 - Procédés de transformation, Editeur : Technip, 1998
Jean-Pierre Favennec, Collectif Technip – « Le raffinage du pétrole -Tome 5 - Exploitation et gestion de la raffinerie, Editeur : Technip, 1998

Semester: 3
Teaching unit: UEF 2.1.3
Matter2: Process intensification
HVW : 22h30 (Course : 1h30)
Credits: 2
Coefficient : 1

Teaching objectives:

1-Understand the principle of process intensification 2-Apply intensification techniques for various processes

Recommended prior knowledge:

Transfer of matter and heat, catalysis, Reactors, unit operations.

Matter content:

Chapter 1. Basics of process intensification

Definitions.Principles and applications of IP.Implementation of process intensification: approach based on equipment or methods.

Chapter 2. Equipment for process intensificationMicroreactors: Oscillating baffle reactors, Rotating disk reactors

Centrifugal absorber

Rotating packed columns

Examples of application of this equipment in different processes

Chapter 3. Methods of Process Intensification

Multifunctional reactors (Reactive distillation, Membrane reactors). Hybrid separations (Membrane-absorption, Membrane-distillation). Examples of applications of these different methods.

Chapter 4. Alternative energy sources Solar energy. Ultrasound. Microwave.

Chapter 5. Other methods of process intensification: New solvents (supercritical fluids, ionic liquids). Examples of application of these solvents.

Evaluation method:: exam 100%.

Bibliographic references:

Stanckiewicz, A.,andMoulijn. Marcel Dekker, Re- engineering the Chemical Processing Plant-Process Intensification. Inc. N.Y 2003.

Semester: 3
Teaching unit: UEF 2.1.1
Material 1: Optimization methods in process engineering.
HVW: 45h00 (Course:1h30, DW: 1h30)
Credits: 4
Coefficient : 2

Introduction
Definition
Examples of optimization in process engineering
Usefulness of optimization in engineering
Definition of an optimization problem
Reminder and definitions:
Objective function-performance criterion;
Local and global extremum;
Gradients;
Hessian Matrix (Hessian);
Optimization constraints.
Properties of objective functions
Unimodal, multimodal functions;
Convex, concave function.
Optimization for functions with a single variable without constraints
Indirect methods: Newton, Quasi Newton, Secant;
Direct methods: Equal intervals, Dichotomy, Fibonacci, Golden section;
-Polynomial approximation methods: Quadratic and cubic approximations;
Davies-Swan-Campey methods (successive evaluations)
4.Optimization for multivariable functions without constraints
Optimization along one direction
Direct methods: Methods with orthogonal directions, Simplex method;
Indirect methods: Gradient method
Optimization with constraints: Linear programming
Definition;
Constraints and feasibility region
Graphics resolution;
Analytical resolution
5.1 Examples

Evaluation mode: Continuous monitoring: 40%; Exam: 60%.

Bibliographic references:

Optimization of Chemical Processes, by Thomas F. *Edgar*, David M. *Himmelblau*.McGraw-Hill Chemical Engineering Series

Semester: 3
Teaching unit: UEF 2.1.2.
Matter1: Reaction engineering II: poly-phase reactors
HVW: 45h00 (Course: 1h30, DW: 1h30)
Credits: 4
Coefficient:2

Teaching objectives:
The student will have acquired knowledge regarding the operation of heterogeneous poly-phase reactors such as absorbers, catalytic reactors, combustion reactors and other heterogeneous two-phase reactors.

Recommended prior knowledge:
Knowledge of basic concepts of homogeneous reactors, chemical kinetics and transfer phenomena is recommended.

Matter content:
Chapter 1. Fluid-fluid two-phase reactors (6 Weeks)
-Introduction ; -Effect of the chemical reaction on the transfer of matter
(Two film theory; Pseudo first order reaction-Hatta number (Ha); Rapid reaction regime-Acceleration factor E; Instantaneous reaction regime-Diagram E versus Ha.); - Calculations of two-phase reactors (batch reactors, piston reactors, perfectly stirred continuous reactors.
Chapter 2. Catalytic fluid-solid reactors (6 Weeks)
- Intraparticle diffusion
(Thiele number; Efficiency).
- Efficiency and transfer of external matter (Effect of the diameter of the catalyst grain; Transfer of external matter).
- Influence of internal diffusion on the reaction (Weisz-Prater criterion); Influence of external matter transfer on the reaction (Mears criterion).
- Fixed bed reactors. ; Fluidized bed reactors.
Chapter 3. Non-catalytic fluid-solid reactors (3 Weeks)
Shrinkingcore model of the sphere.

Evaluation method : Continuous monitoring: 40%; Exam: 60%.

Bibliographic references:

Roustan M : Transfert gaz/liquide dans les procédés de traitement des eaux et des effluents gazeux, Tec § Doc Lavoisier, Paris (2003) ISBN : 2-7430-0605-6
Schweich D : génie de la réaction chimique, Tec ! Doc lavoisier(2001) ISBN : 2-7430-0459-2
R.Missen, C.Mims and B .Saville : Chemical reactions engineering and kinetics, John Wiley and Sons, new York (1999)
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Villermaux J : Génie de la réaction chimique , conception et fonctionnement des réacteurs, 2ème édition, Tec § Doc Lavoisier , Paris (1993) ISBN : 2-85206-132-5
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Froment G and Bischoff KB : Chemical reactor, analysis and design : John Wiley and Sons, New York (1979)

Semester: 3
Teaching unit: UEM 2.1
Matter 1: Process regulation and control
HVW: 45h00 (Course : 1h30, DW: 1h00)
Credits: 4
Coefficient : 2

Teaching objectives:
At the end of this course, the student should be able to master the control of a process and its implementation on a process scale.

Recommended prior knowledge:
Mathematics (Differential equation, symbolic calculation, etc.), Electricity, Instrumentation.

Matter content:

Chapter 1. Analysis of linear control of continuous systems (10 Weeks)
• Introduction to control systems.
• Mathematical reminders (ordinary linear differential equations, Laplace transforms).
• Mathematical modeling of examples of the Chemical process.
• Analysis of the dynamic behavior of the system of first order, second order and those of more complicated dynamics (non-minimum phase delay, etc.)
• Study of the stability of a control system, Ruth Hurwitz criterion).
• Performance of a control system (transient and permanent regime).
• Graphical analyzes of the dynamics of a system (Bode, Nyquist and Black diagram)
• Graphical analysis of stability (gain criterion and phase).
• Techniques for analyzing order by place (Roots).

Chapter 2. Summary of linear control of Continuous Systems. (3 weeks)

Introduction to control by P and PI, phase advance and phase delay.

Chapter 3. Concept on adaptive and predictive control. (2 weeks)

Evaluation method: Continuous monitoring: 40%; Exam: 60%.

Bibliographic references:

Jean Pierre Corriou, Commande des procécédés, 3 éme édition Lavoisier, 2012.
Jean Pierre Corriou, Commande des procécédés, 2 éme édition Lavoisier, 2003.
George Stephanopoulos, Chemical Process ConytolAn Introduction to theory and Ptractice, Prentice/ Hall International, Inc, 1984.

Semester: 3
Teaching unit: UEM 2.1
Matter: Experiment plan
HVW : 37h30 (Course : 1h30, PW : 1h00)
Crédits: 3
Coefficient : 2

Teaching objectives:

Allow good control of experimental manipulations and make the results more significant.

Recommended prior knowledge:

Basic notions of mathematics

Matter content:

Chapter 1: General introduction and factorial designs

1. Introduction

2. What is an experimental design

3. Study domain and response surface

4. Factors

5. Concept of interaction

6. Concept of model and multiple linear regression

7. Full 2k factorial design

   7.1. Example of calculating effects

   7.2. Graphical representation of the effects

   7.3. Matrix Form- Multilinear Regression

8. Application example

Chapter2: Significance testing and model validation

1. Introduction

2. Experimental errors

3. Tests of Significance of Effects

4. Confidence interval of model effects

5. Analysis of variance. Validation of the linear model

5.1. The “ANOVA” table

5.2. Coefficient of determination-Correlation coefficient

6. Application example

Chapter 3: Fractional plans

1. Introduction

2. Designing a fractional plan

3. Fractional Plan Analysis

4. Application example

5. Other plans: Plackett-Burman Plans and Taguchi Plan

Chapter4: Response surface plans

1. Introduction

2. Concept of response surface and isoresponse curves

3. Plans for the study of quadratic models

3.1. Box plan - Behnken

3.2. Centered composite plane

4. Criteria of quality and optimality of an experimental plan

4.1. Calculation of optimal plans

5. Example of application of response surface plans

Chapter 5: Mixing plans

1. Introduction

2. Geometric representation of mixtures

3. Area of study in mixing plans

4. Mathematical models of mixtures

5. Analysis of a mixing plan

6. Application example

7. Mixing designs and design of experiments: mixed designs

Applications

-Introduction to Minitab software + Obtaining the coefficients of a complete design as well as the graphs of the main effects and interactions+ANOVA.

- Fractional plans in Minitab

- Optimization by response surface plans (Box Benkhen+Central composite)

- Use of mixing plans

Evaluation method : Continuous monitoring: 40%; Exam: 60%.

Bibliographic references

Semester: 3
Teaching unit: UEM 2.1
Matter 3: Refining and petrochemical processes
HVW : 22h30 (PW : 1h30)
Credits: 2
Coefficient : 1

Teaching objectives:

• Allow the student to experimentally characterize an oil sample.

• Know the operating principle and important characteristics of the devices used.

Recommended prior knowledge:

Thermodynamics, kinetics, Heterogeneous reactors, heat and matter transfer, Fluid dynamics, heat and matter transfer,

Matter content:

Refining and petrochemicals

PW Nº. 1. Determination of the flash point and flammability temperature of gas oil.

PW Nº. 2. ASTM distillation.

PW Nº. 3. Characterization of a petroleum sample by refractometry.

PW Nº. 4. Analysis of heavy petroleum products by infrared spectroscopy.

PW Nº. 5. Determination of the cetane index and diesel index of a petroleum product.

PW Nº. 6. Determination of aniline point of a petroleum product.

PW Nº. 7. Measurement of the viscosity of petroleum products.

Evaluation method: Continuous monitoring: 100%

Semester: 3
Teaching unit: UED 2.1
Matter 1: matterof choice
HVW: 22h30 (Course : 1h30)
Credits: 1
Coefficient : 1

Semester: 3
Teaching unit: UED 2.1
Matter 2: matter of choice
HVW: 22h30 (Course : 1h30)
Credits: 1
Coefficient : 1

Semester: 3
Teaching unit: UET 2.1
Matter 1: Documentary research and design of the dissertation
HVW: 22h30 (Course: 1h30)
Credits : 1
Coefficient : 1

Teaching objectives:
Give the student the necessary tools to search for useful information to better use it in their end-of-study project. Help them go through the different stages leading to the writing of a scientific document. Show him the importance of communication and teach him to present the work carried out in a rigorous and educational manner.

Recommended prior knowledge:
Writing methodology, Presentation methodology.

Matter content:

Part I-: Documentary research:

Chapter I-1: Definition of the subject (02 Weeks)
- Subject title
- List of keywords relating to the subject
- Gather basic information (acquisition of specialized vocabulary, meaning of terms, linguistic definition)
- The information sought
- Take stock of your knowledge in the field

Chapter I-2: Selecting information sources (02 Weeks)
- Type of documents (Books, Theses, Memoirs, Periodical articles, Conference proceedings, Audiovisual documents, etc.)
- Type of resources (Libraries, Internet, etc.)
- Evaluate the quality and relevance of information sources

Chapter I-3: Locating documents (01 Week)
- Research techniques
- Search operators

Chapter I-4: Processing information (02 Weeks)
- Work organization
- Initial questions
- Summary of the documents retained
- Links between different parties
- Final plan of the documentary research

Chapter I-5: Presentation of the bibliography (01 Week)
- Systems for presenting a bibliography (The Harvard system, The Vancouver system, The mixed system, etc.)
- Presentation of documents.
- Citation of sources

Part II: Design of the dissertation

Chapter II-1: Plan and stages of the dissertation (02 Weeks)
- Identify and delimit the subject (Summary)

- Problems and objectives of the dissertation
- Other useful sections (Acknowledgments, Table of abbreviations, etc.)
- The introduction (Writing the introduction last)
- State of specialized literature
- Formulation of hypotheses
- Methodology
- Results
- Discussion
- Recommendations
- Conclusion and perspectives
- Table of contents
- The bibliography
- Annexes

Chapter II-2: Writing techniques and standards (02 Weeks)

- Formatting. Numbering of chapters, figures and tables.
- Cover Page
- Typography and punctuation
- Writing. Scientific language: style, grammar, syntax.
- Spelling. Improvement in general language skills in terms of comprehension and expression.
- Save, secure, archive your data.

Chapter II-3: Workshop: Critical study of a manuscript (01 Week)

Chapter II-4: Oral presentations and defenses (01 Week)

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

Chapter II-5: How to avoid plagiarism? (01 Week)

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

- The quote
- Paraphrasing
- Indicate the complete bibliographic reference

Evaluation method: exam 100%

Bibliographic references:

1. *M. Griselin et al., Guide de la communication écrite, 2e édition, Dunod, 1999.*
2. *J.L. Lebrun, Guide pratique de rédaction scientifique : comment écrire pour le lecteur scientifique international, Les Ulis, EDP Sciences, 2007.*
3. *A.Mallender Tanner, ABC de la rédaction technique : modes d'emploi, notices d'utilisation, aides en ligne, Dunod, 2002.*
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5. *M. Boeglin, lire et rédiger à la fac. Du chaos des idées au texte structuré. L'Etudiant, 2005.*
6. *M. Beaud, l'art de la thèse, Editions Casbah, 1999.*
7. *M. Beaud, l'art de la thèse, La découverte, 2003.*
8. *M. Kalika, Le mémoire de Master, Dunod, 2005.*